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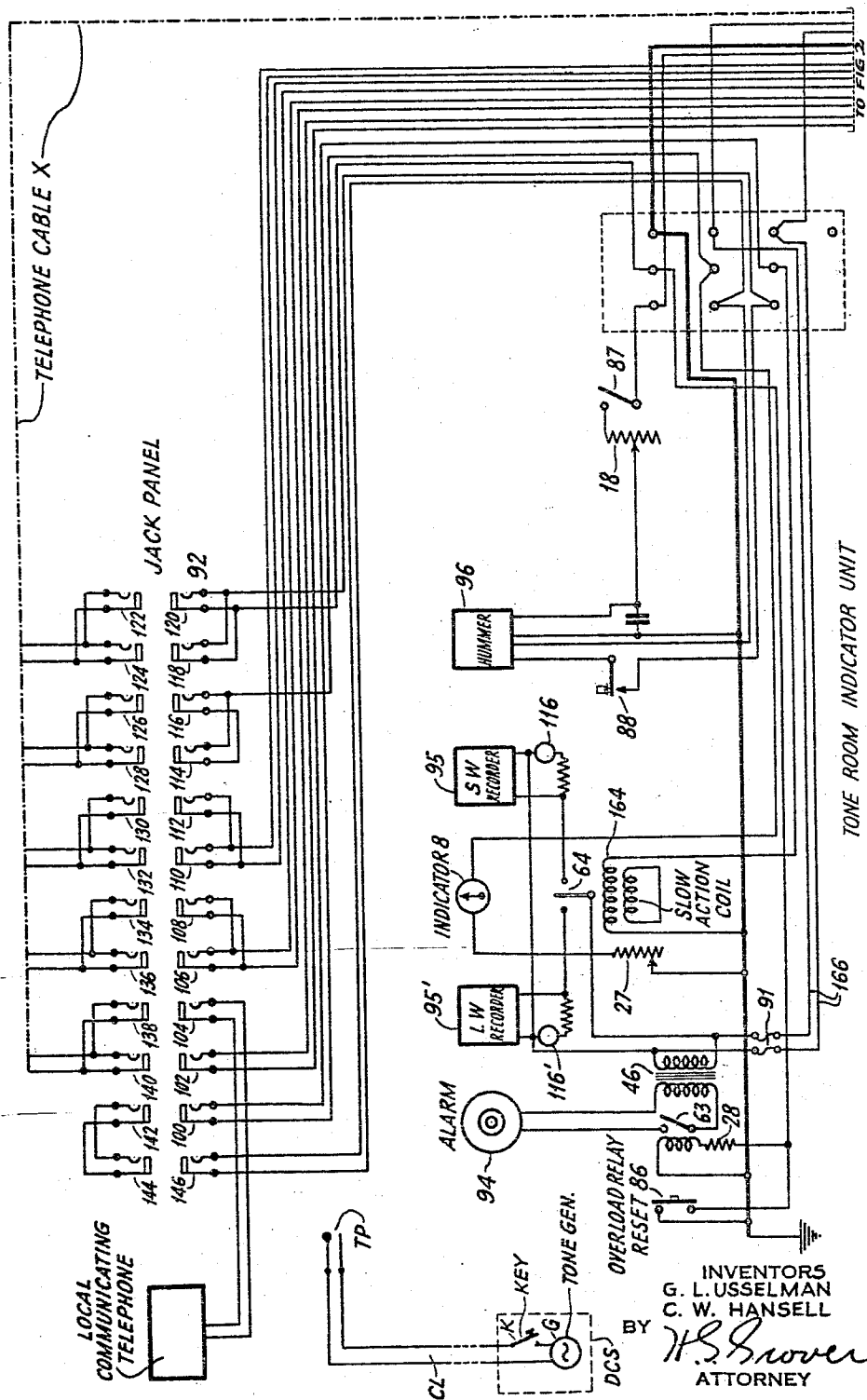
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2,217,628

TRANSMITTING APPARATUS

Original Filed July 23, 1936 20 Sheets-Sheet 1

Fig. 1



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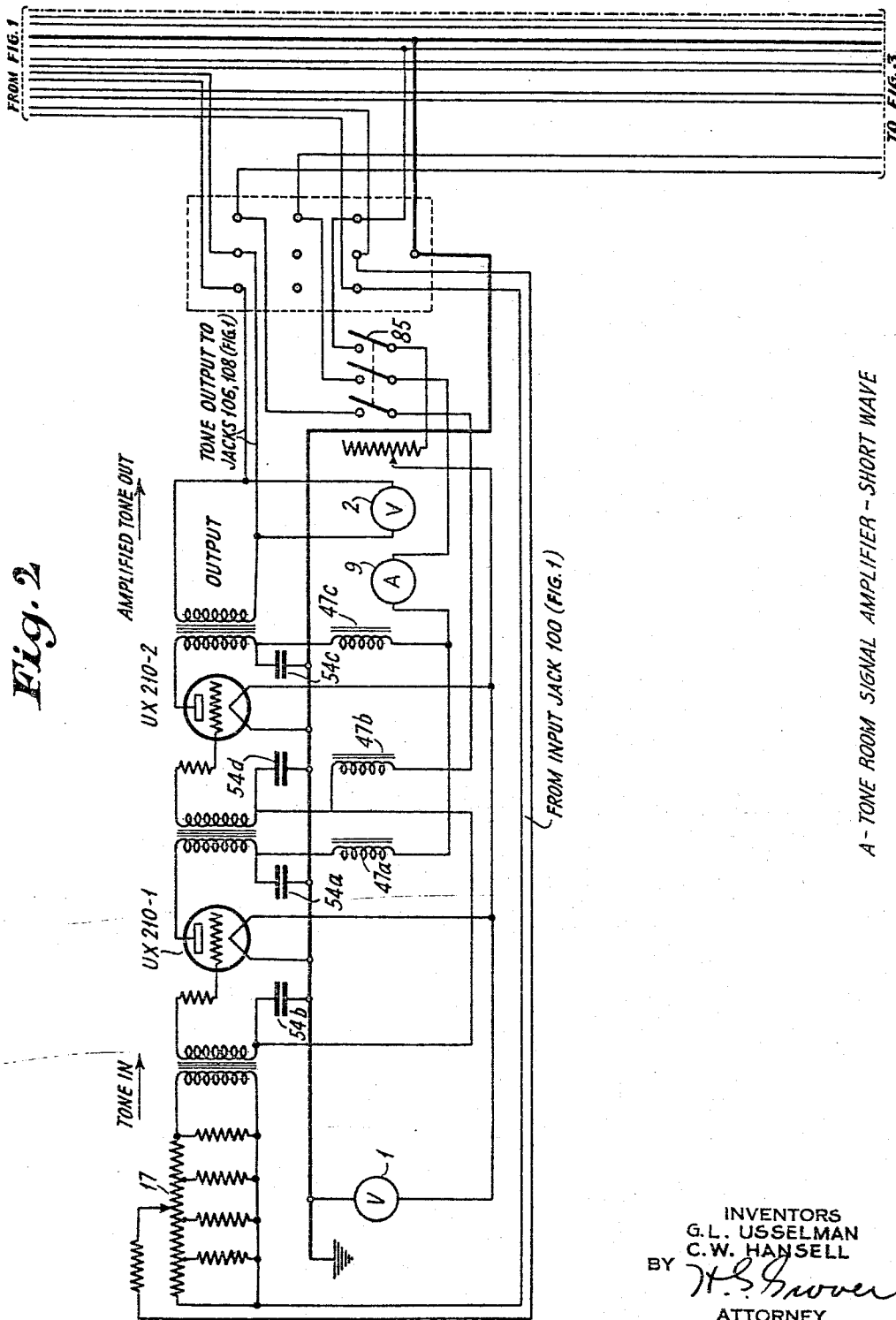
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TRANSMITTING APPARATUS

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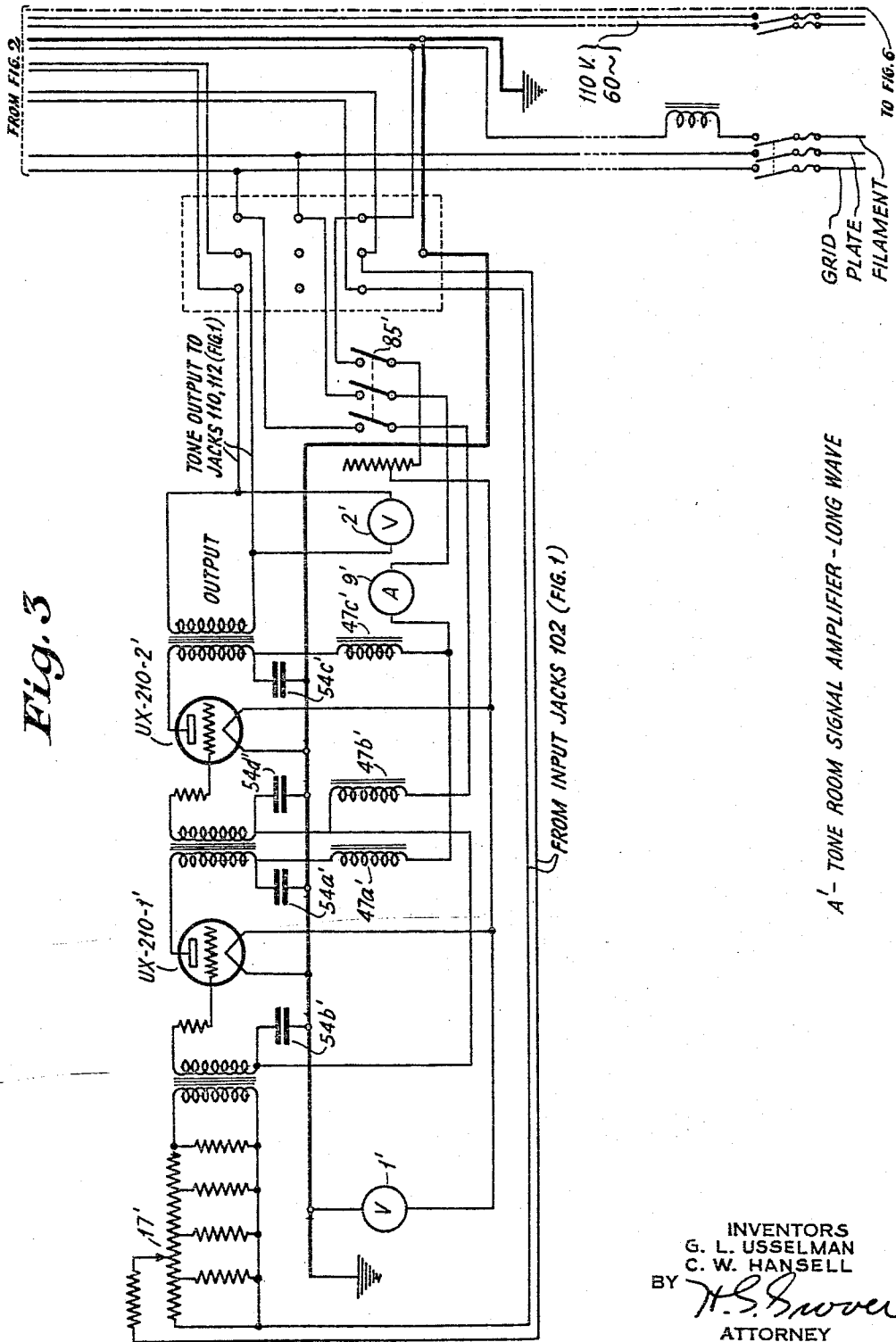
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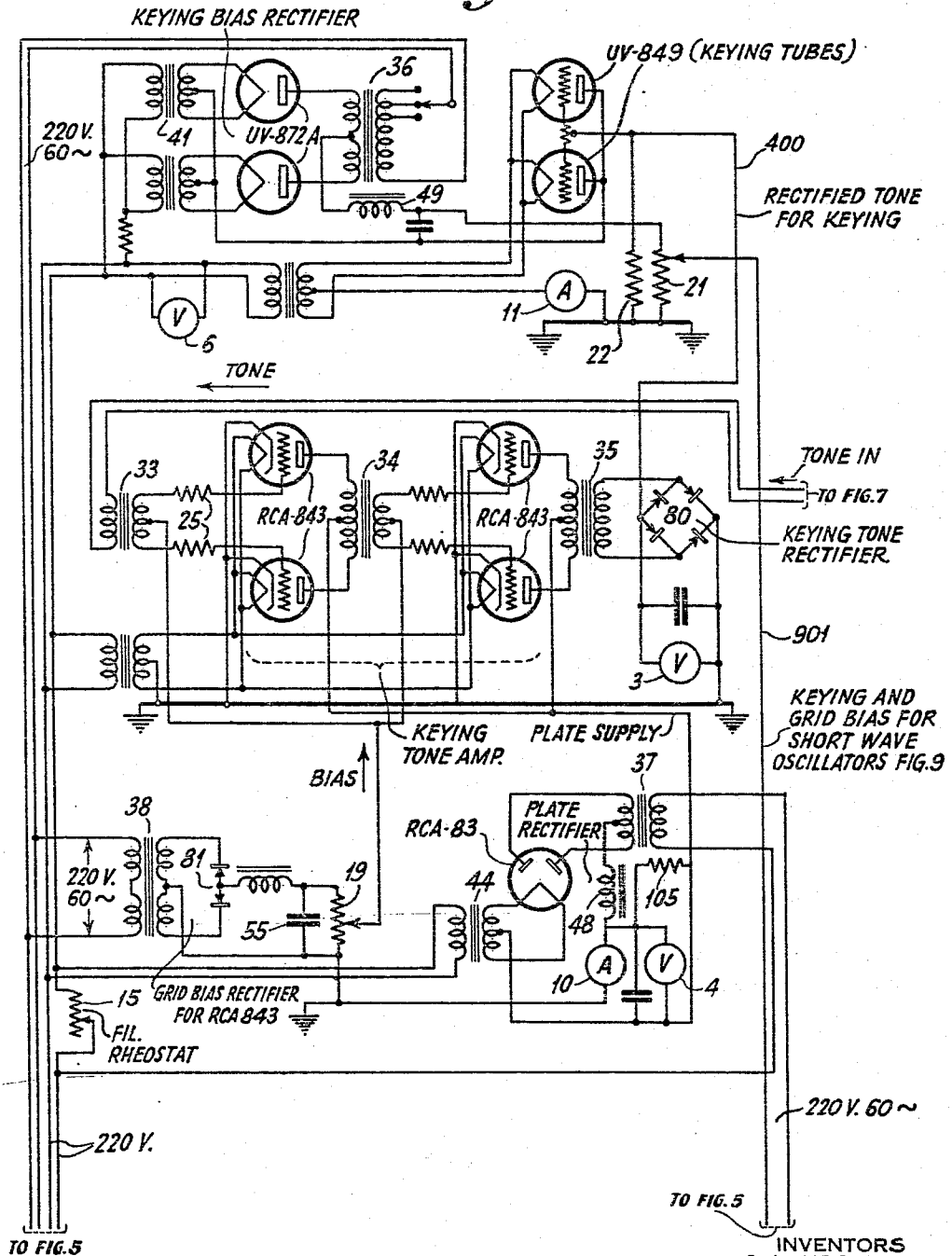
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20 Sheets-Sheet 4

Fig. 4



B-KEYING CIRCUIT

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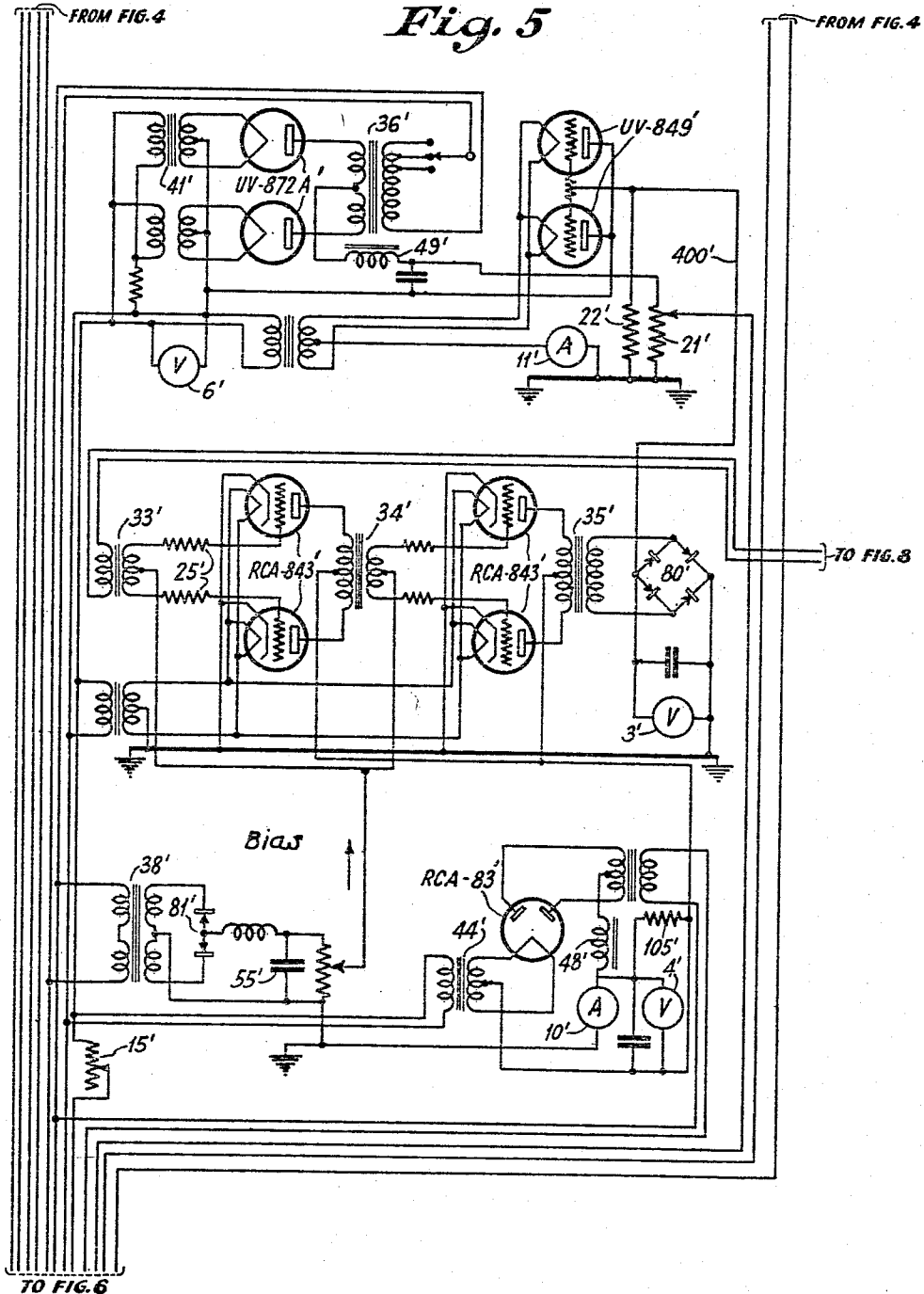
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Fig. 5



B'-KEYING CIRCUIT

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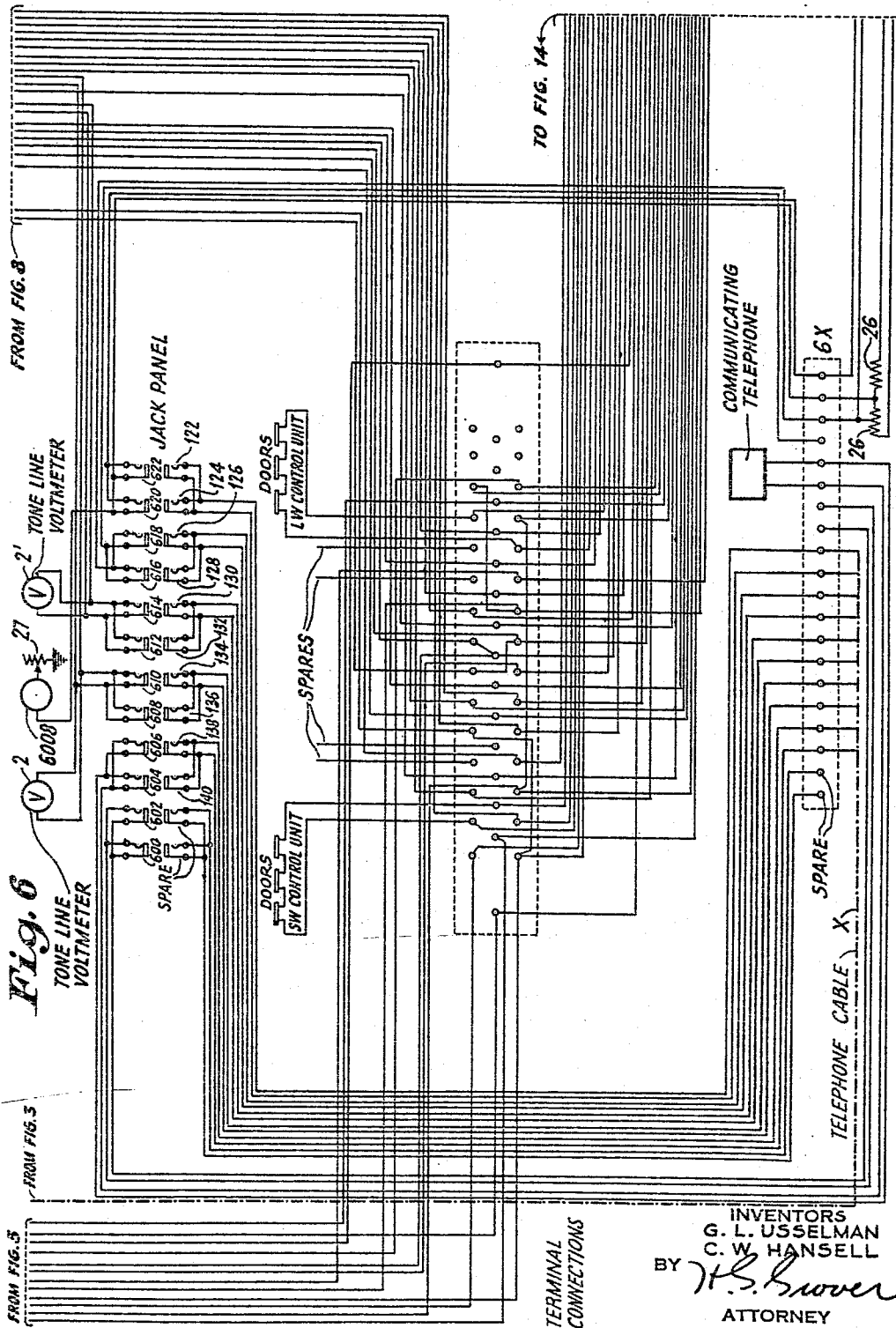
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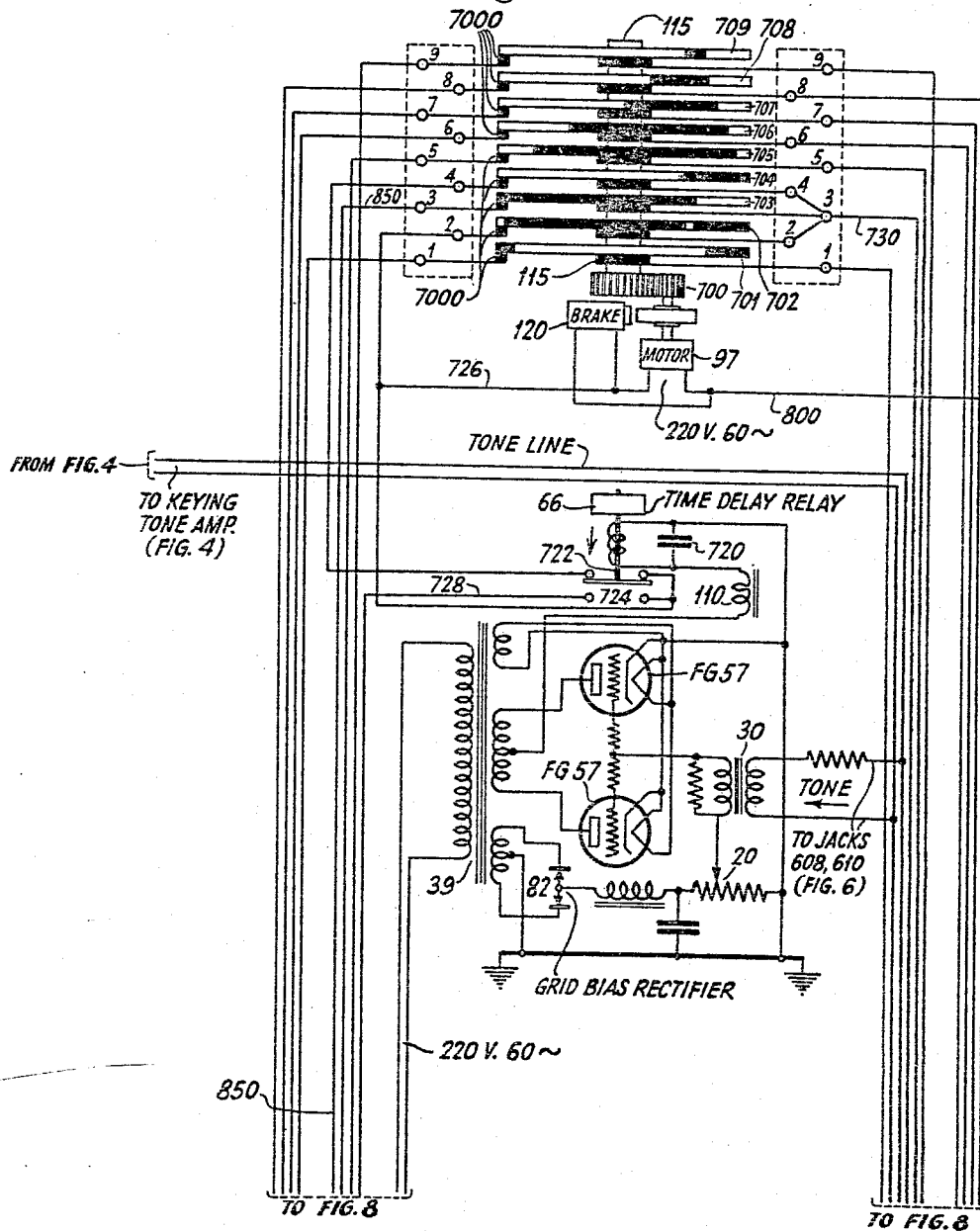
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Fig. 7



E - AUTOMATIC START-STOP CIRCUIT

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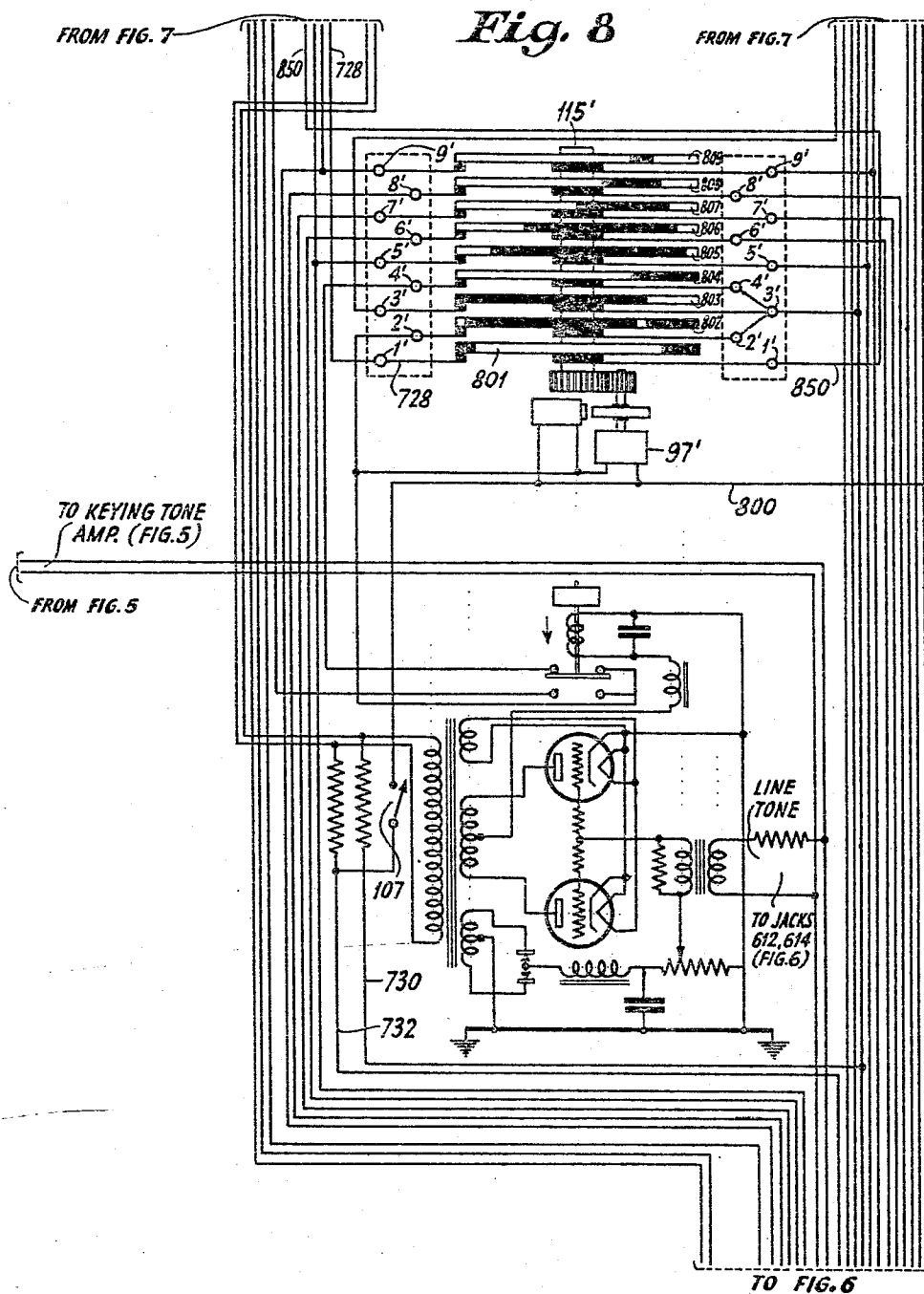
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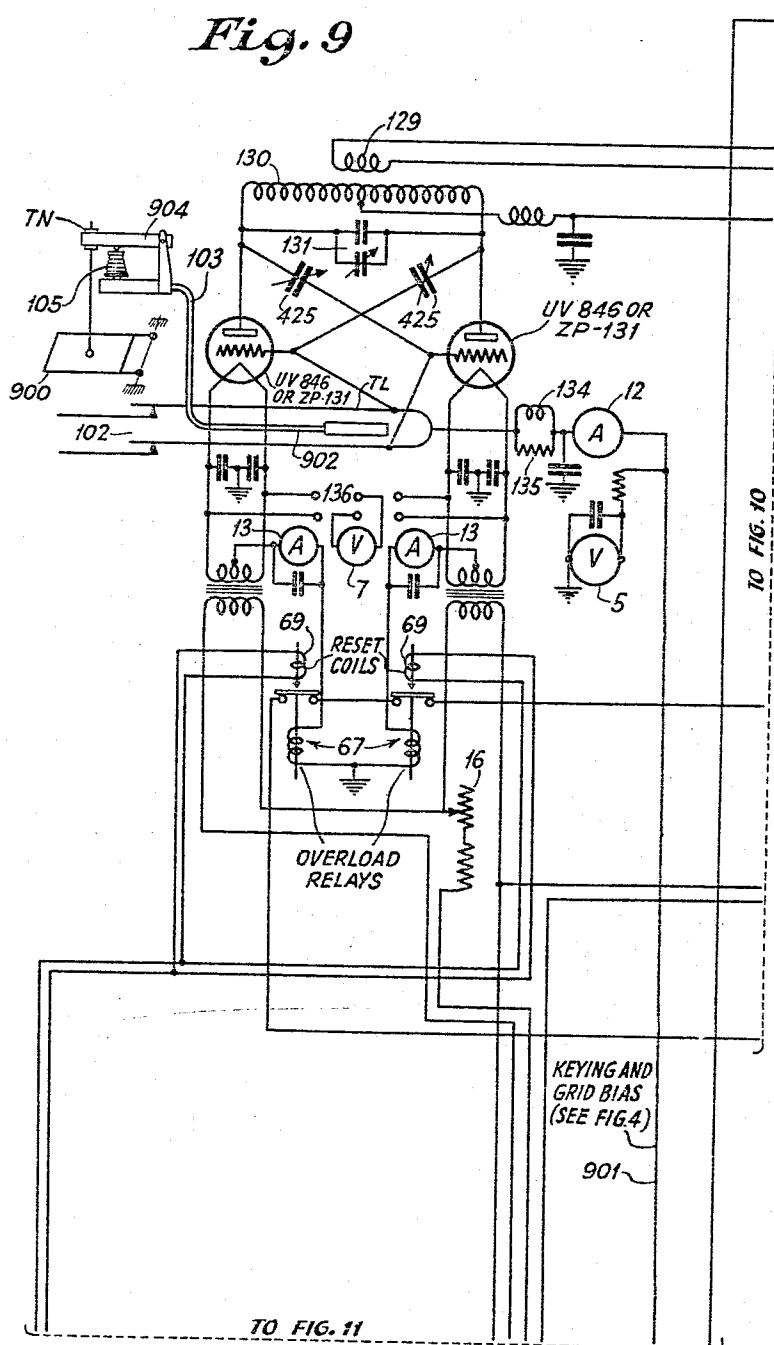
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TRANSMITTING APPARATUS

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Fig. 9



C- SHORT WAVE OSCILLATOR

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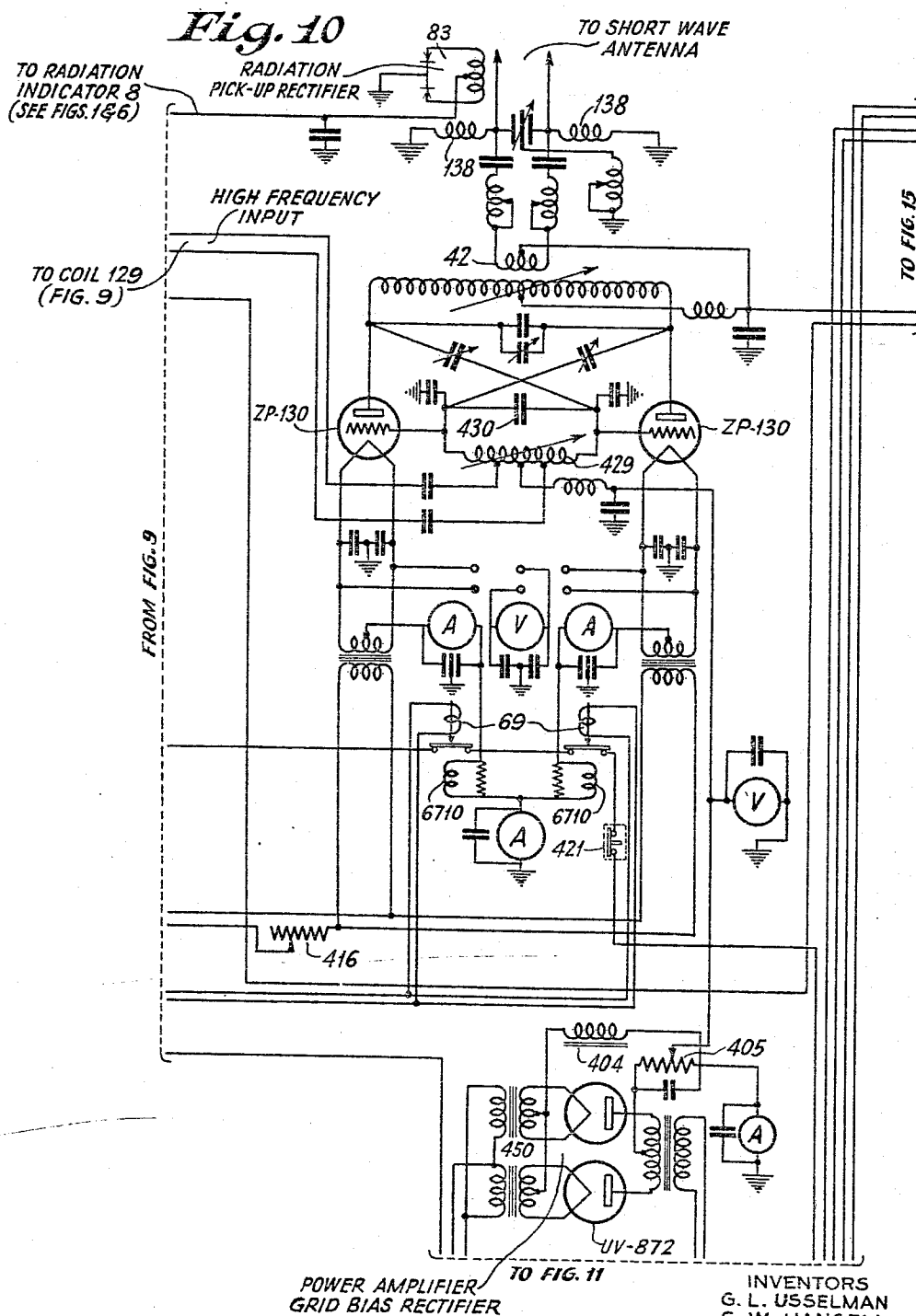
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TOP OF D - SHORT WAVE POWER AMPLIFIER

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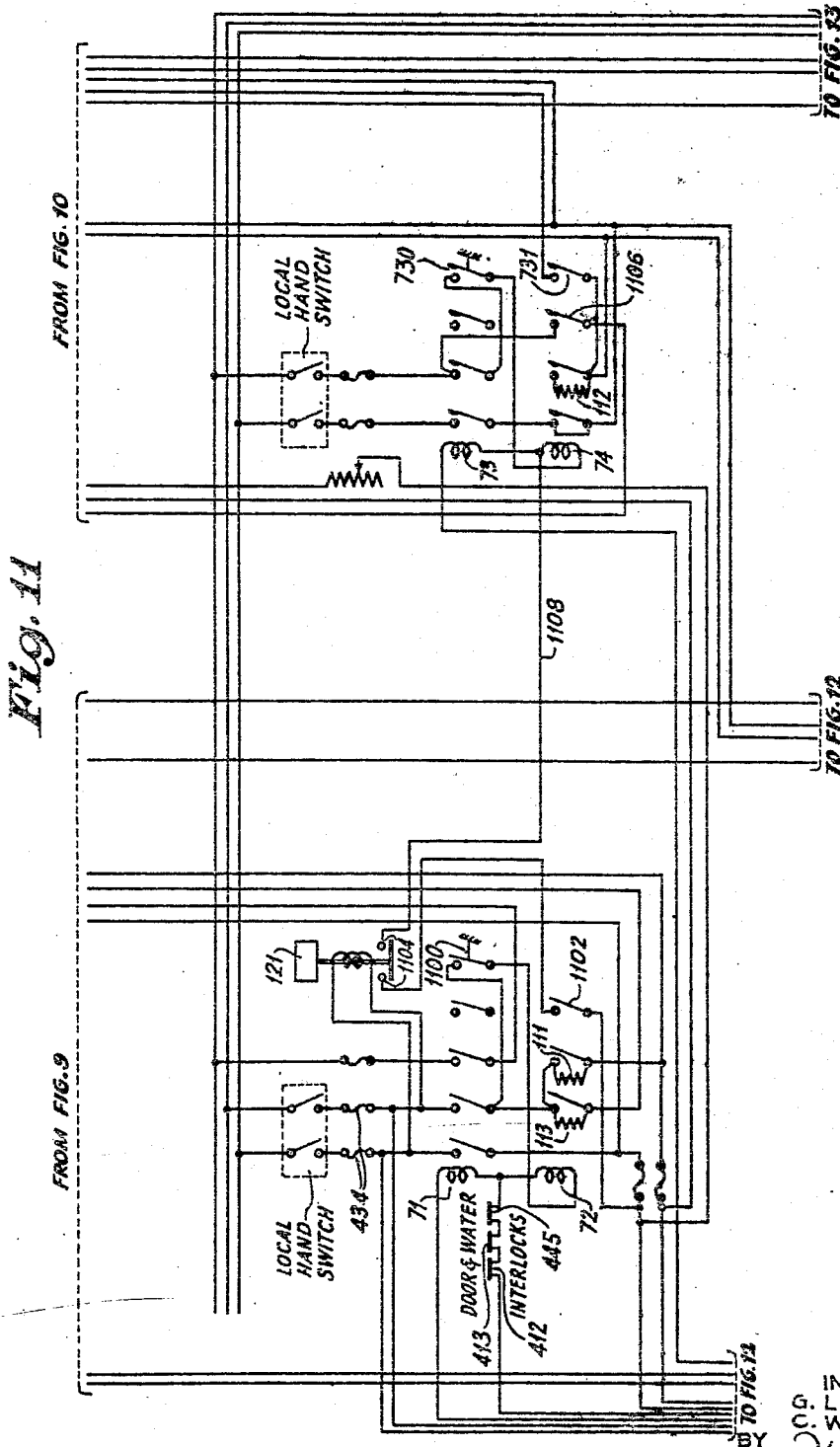
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D - SHORT WAVE POWER AMPLIFIER CONTACTORS

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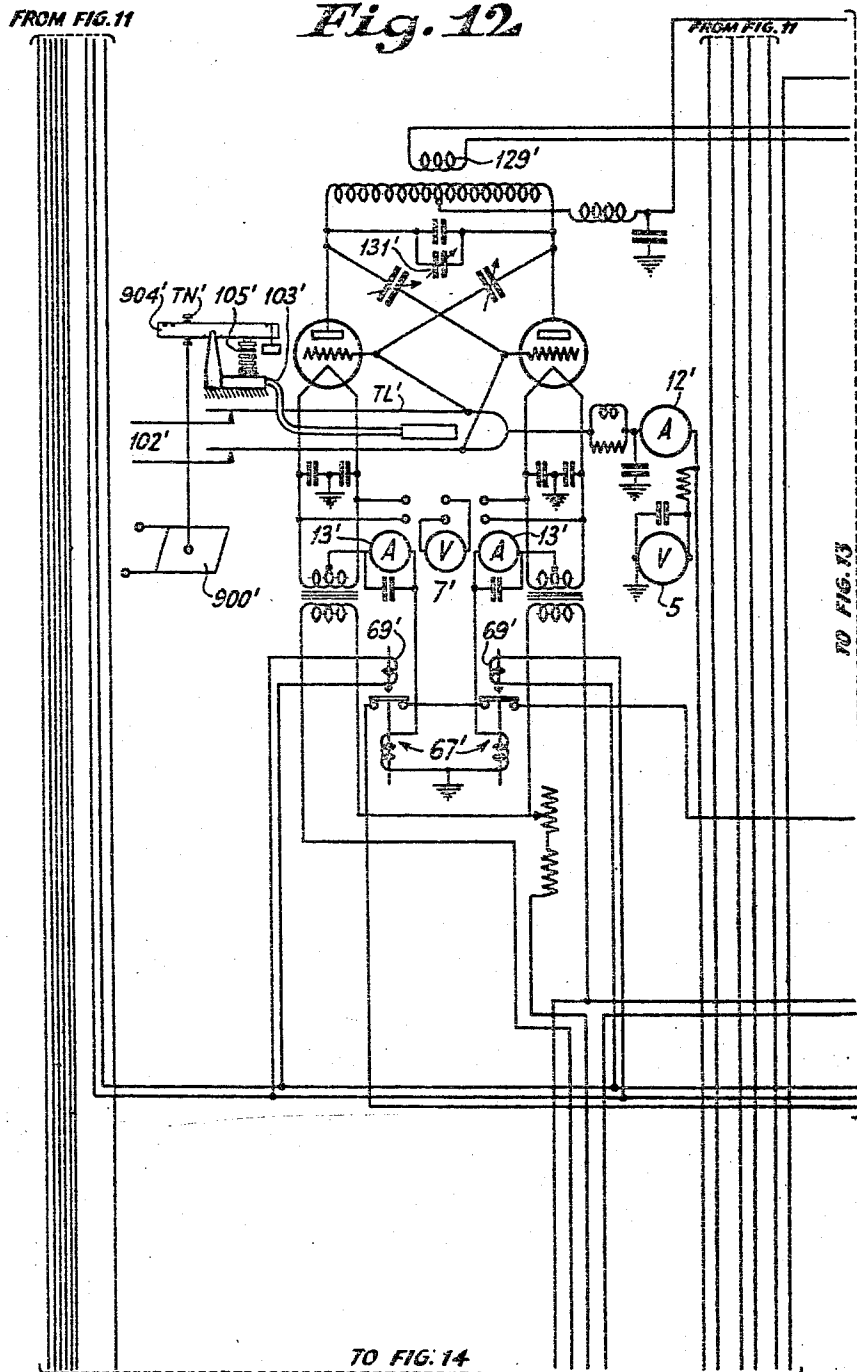
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20 Sheets-Sheet 12



C'- LONG WAVE OSCILLATOR

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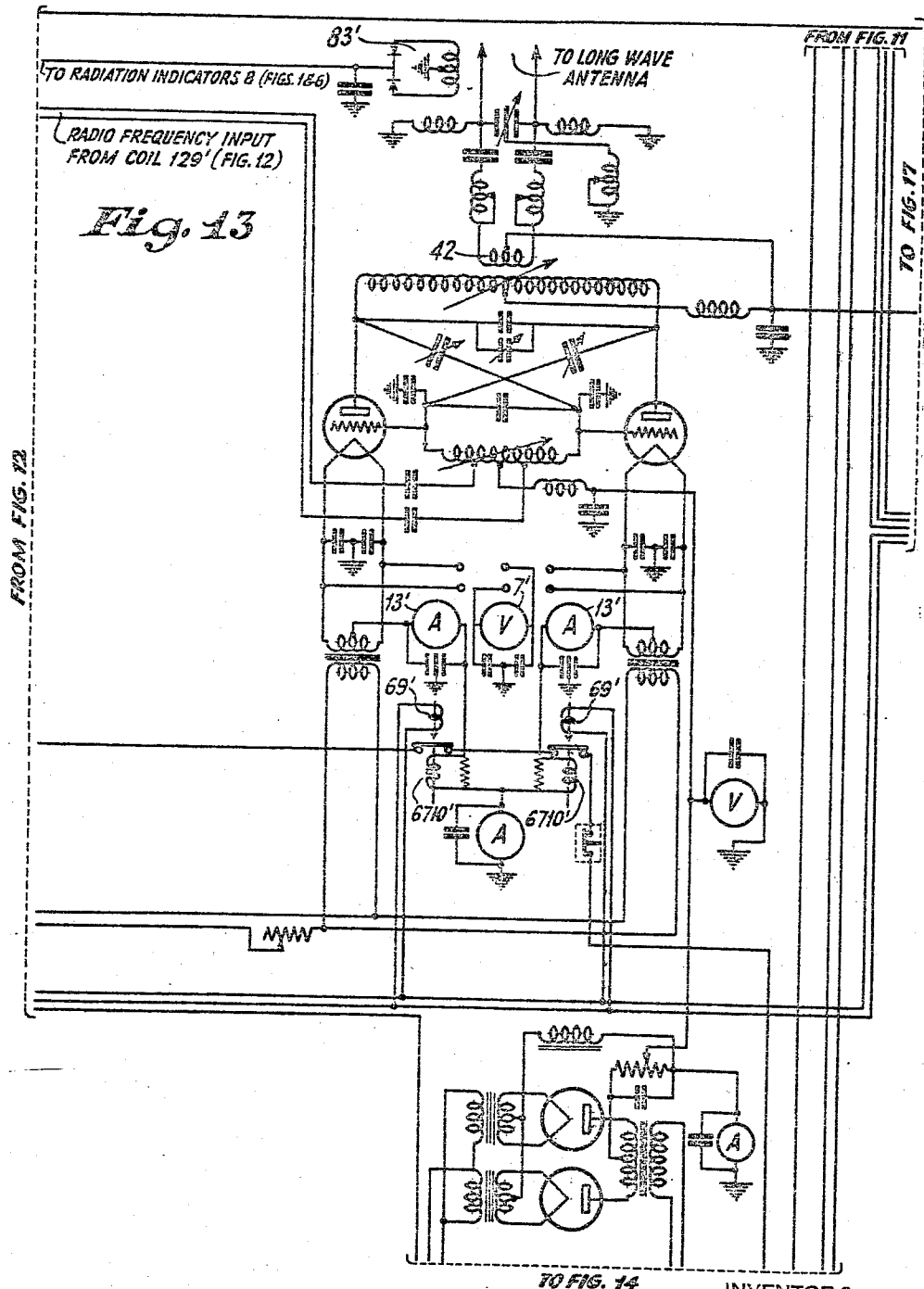
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TOP OF D¹ LONG WAVE POWER AMPLIFIER

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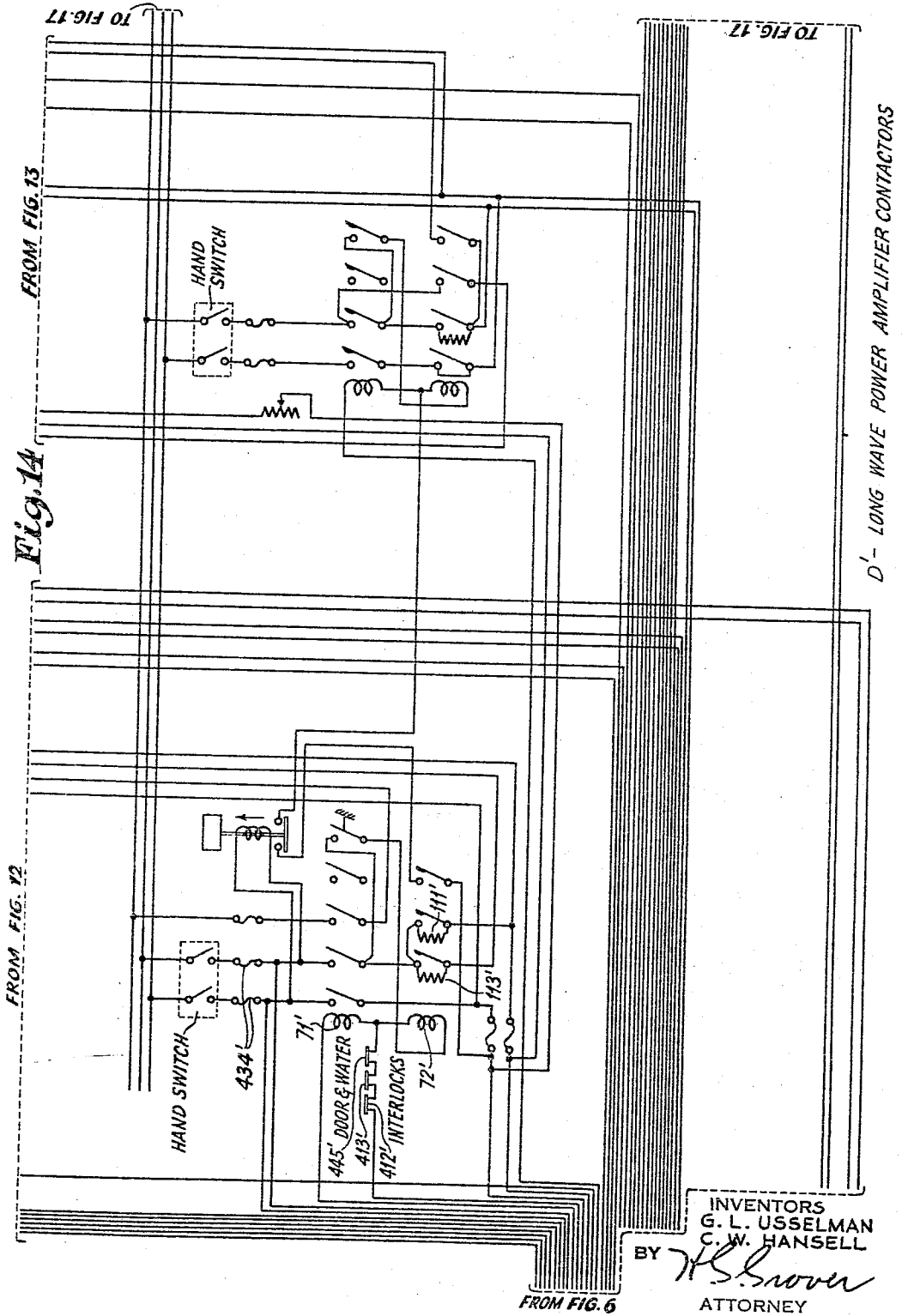
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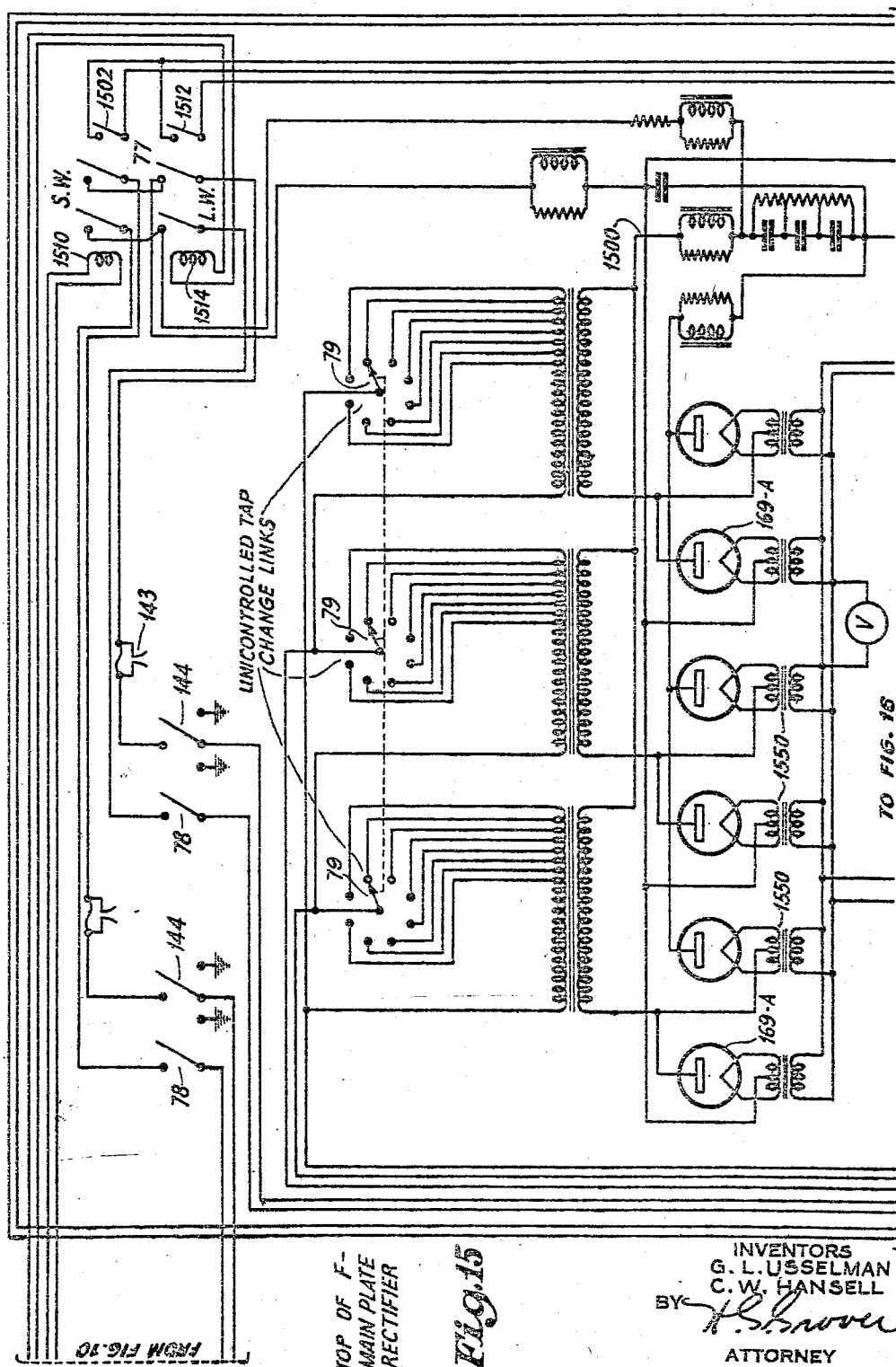
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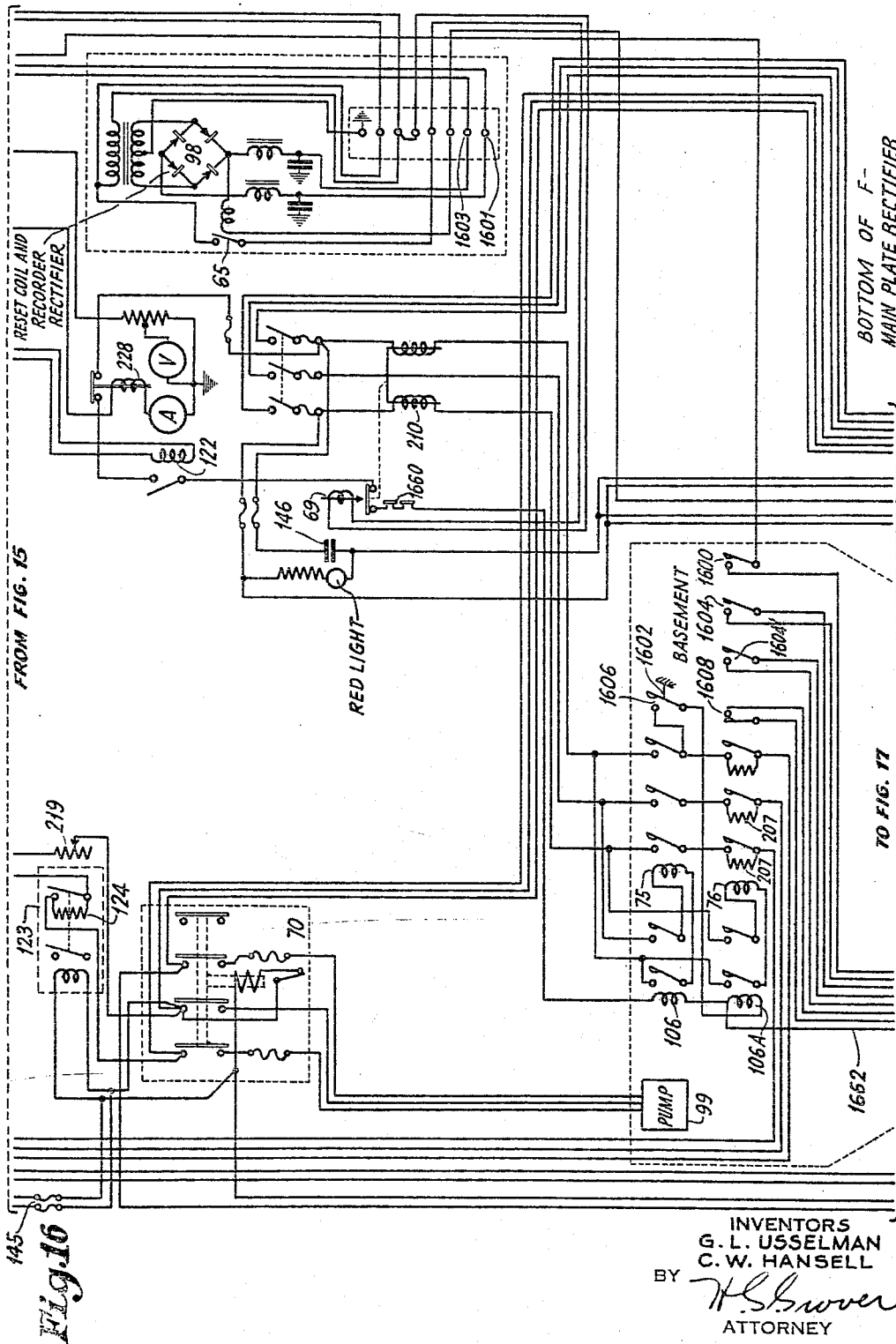
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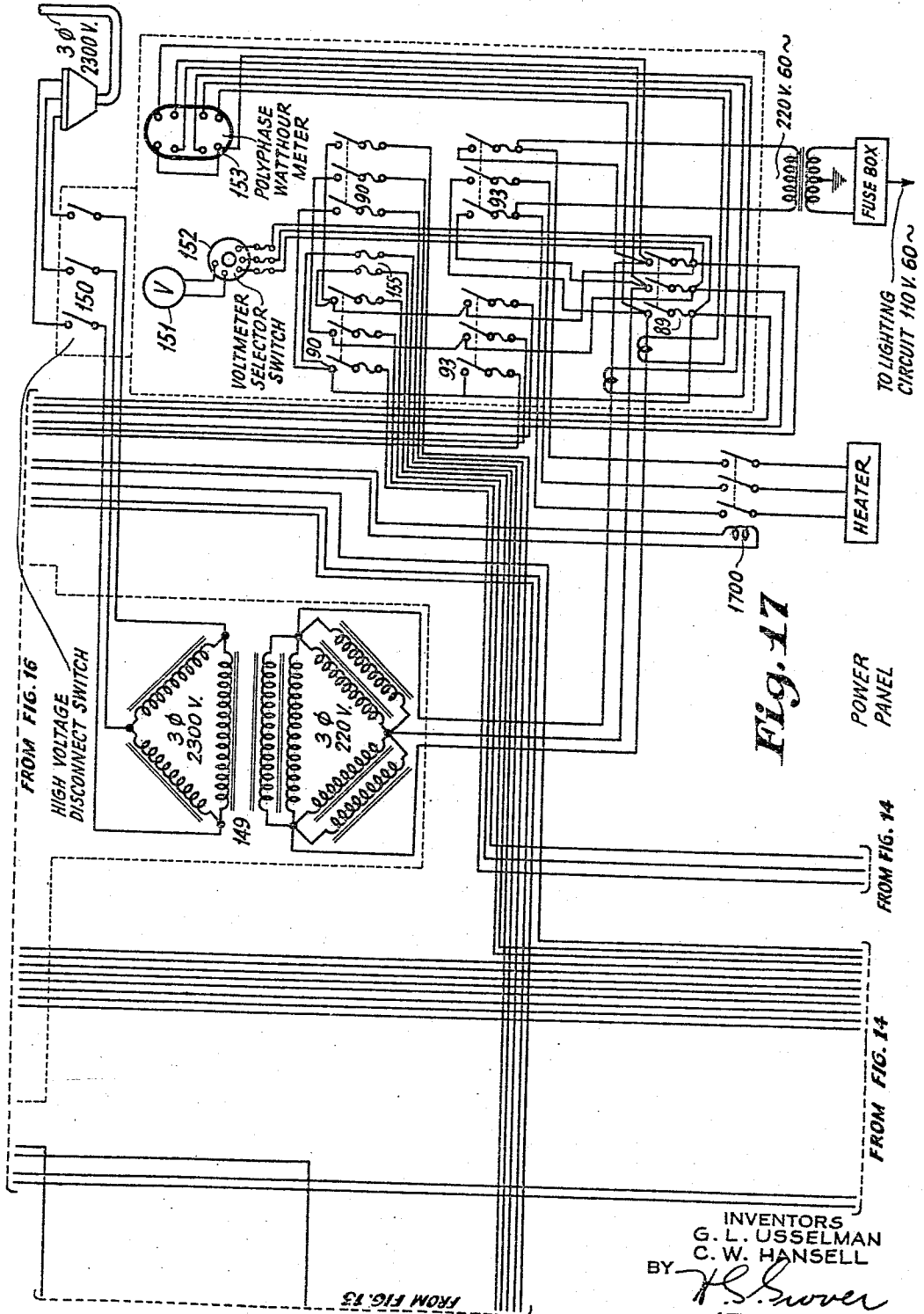
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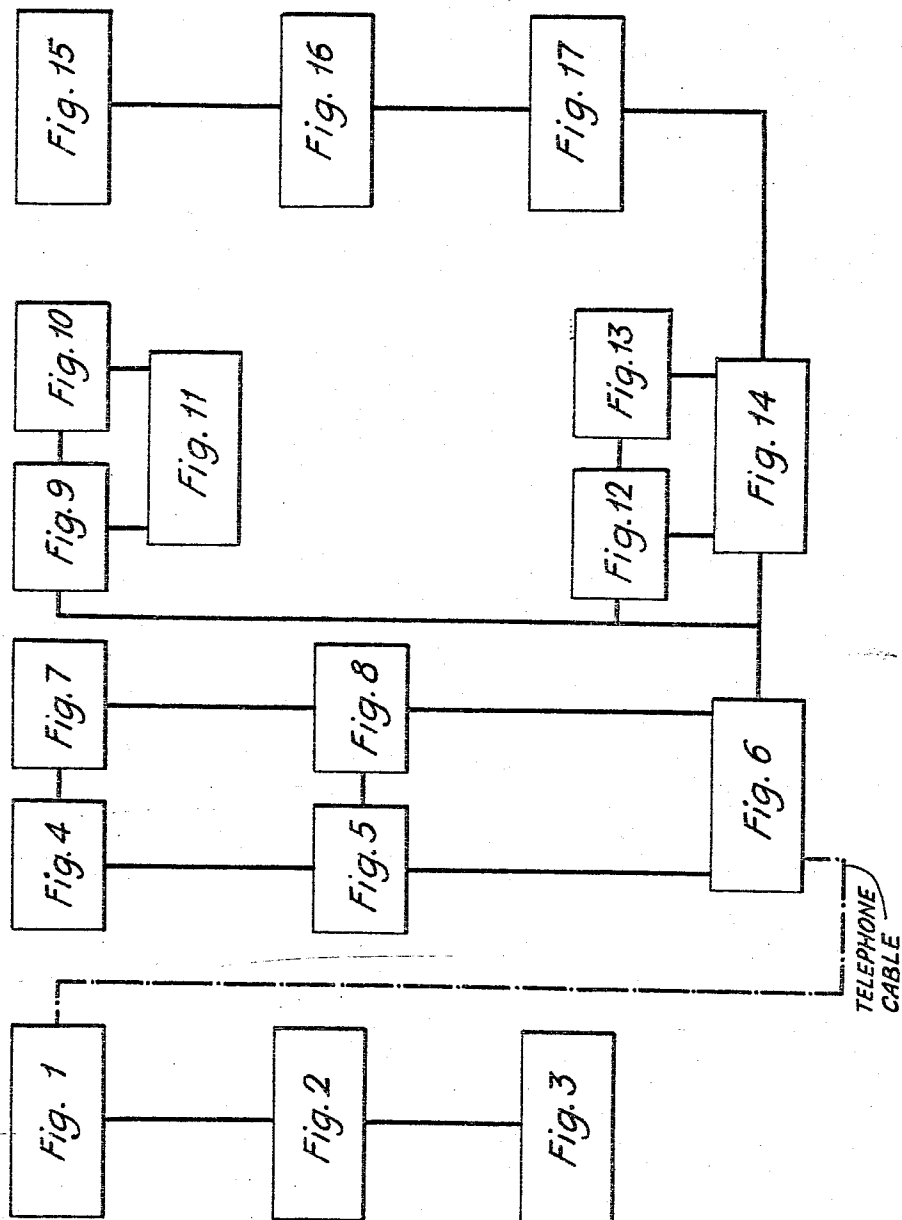
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Fig. 18



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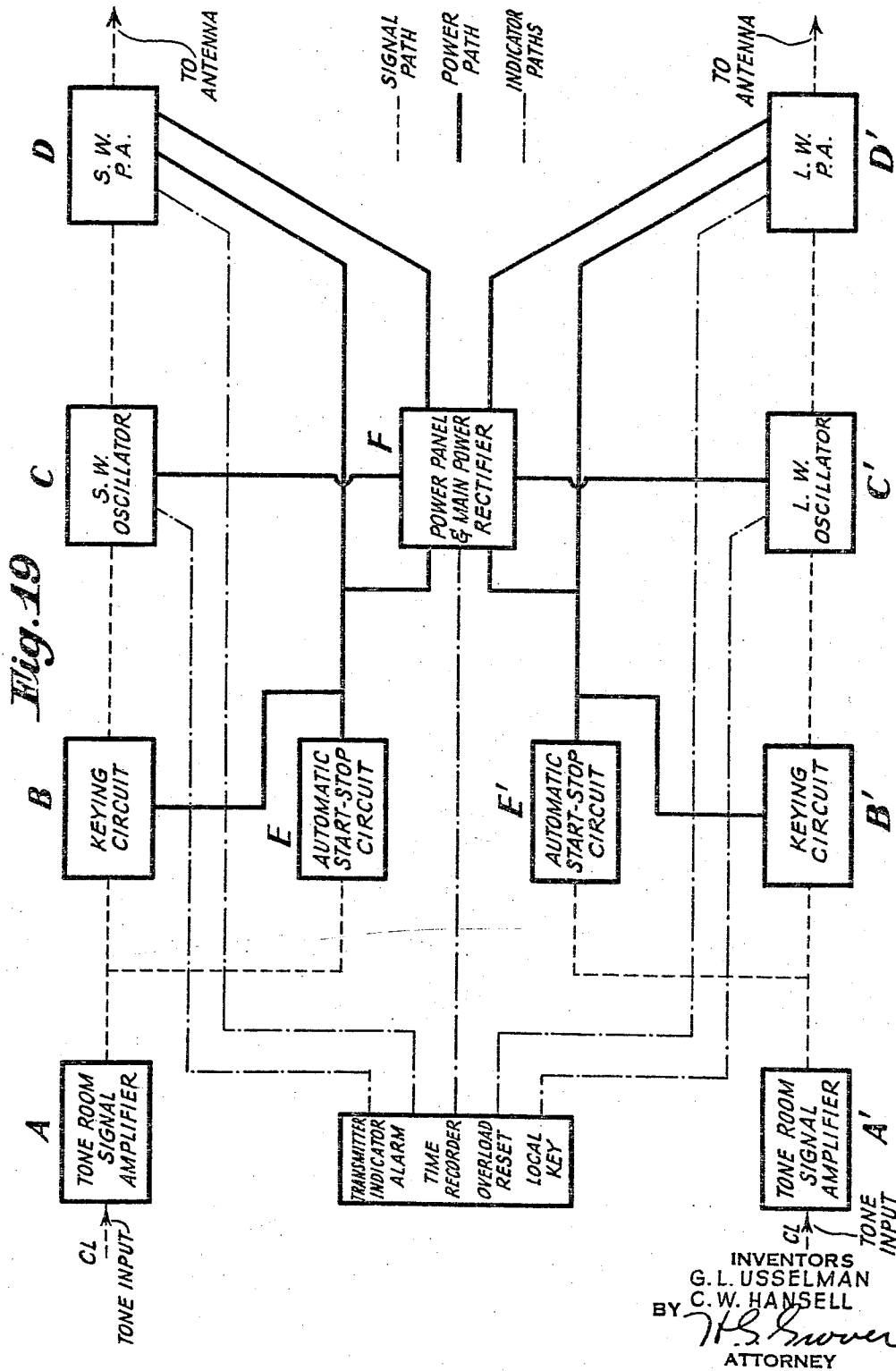
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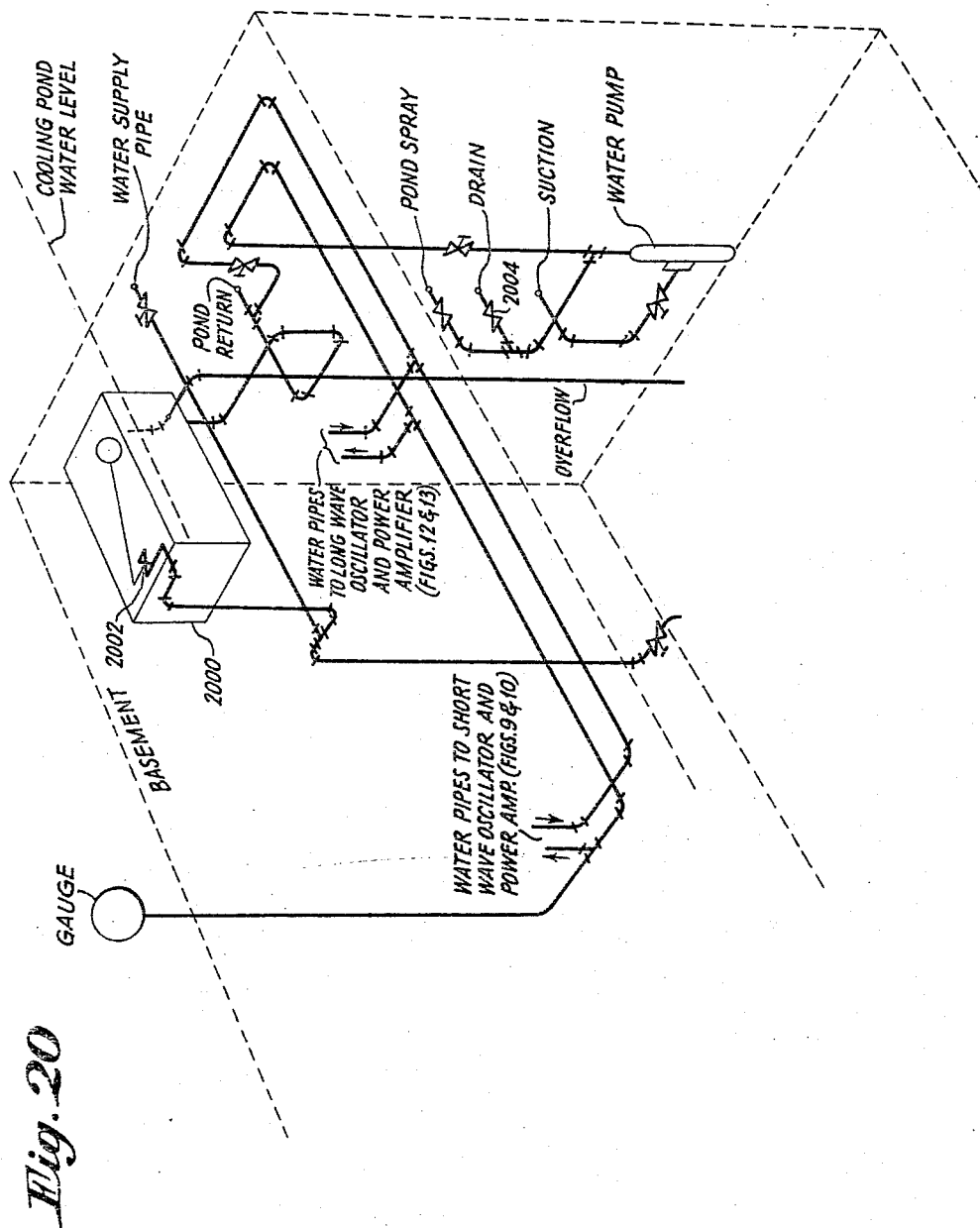
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UNITED STATES PATENT OFFICE

2,217,628

TRANSMITTING APPARATUS

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Application July 23, 1936, Serial No. 92,130
Renewed May 25, 1939

22 Claims. (Cl. 250—17)

Our present invention relates to control of high frequency apparatus and is particularly directed towards the remote control of high frequency radio transmitters.

5 An object of our present invention is to provide a system for automatically starting up a high power radio transmitter. Preferably, in effecting this object we provide an arrangement whereby an operator at any convenient control point may, by application of a tone or a few
10 signal characters, cause proper sequential excitation of the various parts of a high power, high frequency transmitter. This is particularly desirable in communications plants employing a large number of transmitters for
15 during peak signalling loads and, for example, after electrical storms when there may be power failure, it is practically impossible to provide a sufficient number of skilled personnel to properly start up a large number of transmitters in a
20 short period of time.

A further object of our invention is to provide means for remotely controlling, that is to say, for placing into operating condition and for
25 causing shut down, one of several radio frequency transmitting systems employing a common plate voltage rectifier.

Another object of our present invention is to provide an arrangement whereby, for full power
30 transmission, it is possible to start up and connect only one radio frequency channel to the common rectifier and whereby the starting operation of one channel prevents, during the starting and running period of the desired channel, operation of the other channel.

Another object is to provide a system whereby the operative channel of the system referred to hereinabove is shut down upon absence for a
40 predetermined time, of signal or control voltages. Also in such a multi-channel system, it is a further object of our invention to provide, in order to conserve time, an arrangement whereby one channel may be started towards its operating condition when the other has been partially shut down and is completing its shut down
45 cycle of operations.

Further objects of our invention are to provide improved means for indicating the operation of any one of several channels of our system; to
50 provide time indicating means to indicate the time of operation of any one of several transmitters; to provide an indicating system to show which of several transmitters is in operating condition
55 and to provide apparatus for insuring correct

sequential excitation of various elements of a high powered radio transmitter.

Other objects, features and advantages of our present invention will be apparent as the further description thereof proceeds.

In the accompanying drawings:

Figures 1 to 17 inclusive, when placed together as shown diagrammatically in Figure 18, constitute a wiring diagram of our improved remote control system wherein one of two radio
10 frequency channels may be started to the exclusion of the other and wherein the other may be started at a time when the one is completing its shut down cycle of operations;

Figure 19 is a block diagram showing, generally, the signal power and indicator paths involved in the apparatus of Figures 1 to 17 inclusive, and

Figure 20 is a schematic diagram of an improved water cooling system preferably employed
20 in connection with oscillators and power amplifiers of our remote control system.

I. GENERAL DESCRIPTION (FIGURE 19)

In general, the system described herein may
25 be considered as two transmitters using the same main plate rectifier F. In an installation which we have set up and operated one part or radio frequency unit or channel operates on a frequency 6725 k. c. and the other part unit or
30 channel operates on a frequency of 13,420 k. c. These circuits are so arranged that only one frequency or channel can be operated full load at one time. If desired, provisions are made for running both transmitters at reduced load.

The general arrangement of circuits and a brief outline of operation of the remote control transmitter may be more clearly understood by referring to Figure 19. Assuming that it is desired to transmit on the shorter wave of the
40 two radio frequency channels provided, and assuming further that the radio frequency units and common rectifier are located at Rocky Point, Long Island, and are to be controlled from New York city some sixty miles away, a tone signal; namely, an alternating current of audio frequency keyed by hand or keyed by an automatic keyer, printer or by a multiplex keying
45 system; from New York is plugged into signal amplifier A, which is in the tone room at, say, building #1 Rocky Point. The output of A is plugged into a line which is connected to the short wave side of the radio transmitter located in another building, say, building #51. This
55

supplies tone signal to keying circuit B and to automatic start-stop circuit E.

Circuit E then automatically starts up the short wave transmitter which includes the following: (B) keying circuit, (C) short wave oscillator, (D) short wave power amplifier and (F) main plate rectifier. After the transmitter has completed the start-up operation (which may be adjusted to take about one and one-half minutes), the signal path continues on through the keying circuit (B), oscillator (C), power amplifier (D), and thence out to the antenna.

The transmitter will shut down after a definite adjustable time delay (for example four minutes), when the tone signal has been removed. The part of the transmitter which is not running cannot start up until the part which is running has shut down, although the signal for the starting-up transmitter may be applied before the running transmitter has shut down.

To transmit on the longer wave, the received keyed tone signal is plugged into amplifier A' (Fig. 19). The tone is then fed to the start-stop circuit E' and keying circuit B'. The main power rectifier F is then used to supply power to the long wave channel. The unit T₁ of Figure 18 represents indicating apparatus described in greater detail in connection with the lower part of Figure 1.

II. DETAILED DESCRIPTION OF TRANSMITTER UNITS AND CIRCUITS

Tone room units (Figs. 1, 2 and 3)

This equipment is located in the tone room and includes the following units: two identical tone signal amplifier units (Figs. 2 and 3); one indicator unit (Fig. 1) and one jack panel (Fig. 1).

Each tone signal amplifier unit (Figs. 2 and 3) is a two stage transformer coupled audio amplifier using tubes UX-210-1, UX-210-2 and UX-210-1' and UX-210-2'. The tone amplifier units are equipped with volume control 17 and 17' and the outputs are supplied with 5 volt rectifier type meters 2 and 2' for measuring the output voltage of the amplifiers. Two 100 ma. D. C. ammeters 9 and 9' are supplied to measure in common the plate current of both UX-210 tubes in each tone amplifier.

A 10 volt D. C. voltmeter is supplied to measure the filament voltage of both tubes of the tone amplifier A (Fig. 2) and a voltmeter 1' is supplied for amplifier A' (Fig. 3). 250 volts plate power, 30 volts grid bias and 8 volts D. C. filament power are supplied from one of the standard tone room switch and fuse boxes to the three pole switches 85 and 85', one being located in each tone amplifier unit.

The plate power of each tube of tone amplifier A has individual filtering coils 47a, 47c and condensers 54a, 54c, while the grid filtering coil 47b and condensers 54b and 54d are connected to be common for both tubes in the amplifier. Similar filtering, indicated by corresponding primed numbers, is provided for amplifier A' (Fig. 3). Each amplifier unit is provided with a terminal board (not shown) and the apparatus in the back is covered by a shield or cover (not shown).

The tone room indicator unit (Fig. 1) contains the following equipment: one push-button switch 86 for resetting overload relays, one alarm bell 84 with bell transformer 48 and relay 83, two time recorders 95, 95', respectively for the short and long wave transmitters, for registering hours, and a polarized relay 64 to operate

the time recorders selectively, one 15-0-15 D. C. milliammeter 8 to indicate which frequency is being radiated, i. e., whether the short or long wave transmitter is in operation, two small signal lights 116, 116' of the telephone switchboard type to indicate when the plate power is applied to either transmitter, one hummer buzzer 96 with a power supply switch 87 and a series resistor 18 for reducing the voltage supplied, and one telegraph key 88 for keying the hummer output.

The jack panel (Fig. 1) has two rows of twelve jacks each, the individual jacks being numbered 100-146 inclusive. The bottom row of jacks is connected to the two tone signal amplifiers of Figures 2 and 3 and to the tone room indicator unit of Figure 1. The upper row of jacks, except the spare terminals 142, 144, is connected to the cable X (Fig. 1) leading to the terminals 6X shown in Figure 6. The terminal connections of Figure 6 lead to the jack panel of Figure 6.

Control unit (Figs. 4, 5, 7 and 8)

The control unit includes the apparatus at B, E, E' and B', Figure 18, and this apparatus is shown in greater detail in Figures 4, 5, 7 and 8.

This unit is constructed so as to be divided into right and left halves by a partition (not shown) inside of the unit. The apparatus of Figures 4 and 7 is located in one half and the apparatus of Figures 5 and 8 is in the other half. All apparatus access doors on the left half of the unit are interlocked with the lefthand transmitter which may be assumed to be the low frequency transmitter and all such doors on the right half are interlocked with the righthand or high frequency transmitter. Also in construction, the meters on the left half of the panel should be connected to circuits in the left half of the unit and the meters on the right half of the panels should be connected to circuits in the right half of the unit.

Each half of the control unit contains principally two circuits, these are the automatic start-stop circuit and the keying circuit. On the front of the unit should be placed the meter and rheostat panels and the jack panels. A folding shelf should be mounted just below the jack panel for the use of test meters, telegraph key, notebook, etc. A storage compartment may be located under this shelf, and in the front part of the unit. This compartment may be provided with doors. The space in the lower rear part of the control unit may be occupied by the grid bias resistor unit for the transmitter oscillators and the main terminal board for the control unit and the small terminal board for the jack panel.

The automatic start-stop circuit for each channel consists of three parts. The short wave channel will be described in detail and from this description the long wave channel may be understood since the primed numbers indicate corresponding apparatus in the long wave circuit. In general, this statement applies throughout the specification, exceptions being noted as they occur. The first part of the short wave automatic circuit consists (see Fig. 7) of a grid controlled or "Thyratron" rectifier using two FG-57 tubes and a full wave copper oxide bias rectifier 82. These two copper oxide rectifiers have a common multi-winding power transformer 39. The grids of the FG-57 tubes are excited from an audio frequency input transformer 30. The second part is a time delay relay 66. This relay receives its control coil current from the FG-57 rectifier through iron cored choke coil 110 and the relay 75

contacts control the operation of the control motor 97.

The third part of the automatic start-stop circuit is the drum controller 115 and its driving motor 97.

The drum controller consists of nine rotating contact disks (701—709) inclusive mounted on a common insulated shaft which is driven by the control motor through a reducing gear 700. The contact disks 701—709 perform the function of starting and stopping the transmitter in a regular sequence and provides certain interlocking features, to be explained more fully later. A small switch 107 (see Fig. 8) connected in the common power lead of the two control motors 97, 97' is provided to stop either motor in any position.

Keying circuit

The keying circuit consists of three parts. Specific reference is made to the short wave keying circuit of Figure 4. The first part thereof is the tone signal amplifier-rectifier 33, 25, 34, 35, 80. This is a two stage, transformer coupled push-pull type amplifier using a total of four RCA-843 heater type tubes. The audio input transformer 33 of this amplifier is connected in parallel with the audio input transformer 30 (see Fig. 7) for the FG-57 tubes of the automatic start-stop circuit and to a tone signal input jack, such as 608, 610 of Figure 6 which may be connected through cable X and patch cords to either tone amplifier output jacks 106, 108 or 110, 112. The output circuit of this amplifier (33—35) Figure 4 is provided with a copper oxide rectifier 80 to rectify the amplified tone signal. The rectifier 80 delivers a negative D. C. voltage bias supply which still retains the dot and dash characters for keying the next set of tubes UV-849 in the keying circuit. Rectifier 80 is provided with a 300 volt meter 3 for measuring the output signal voltage.

The second part of the keying circuit is the power supply for plate and grids of the RCA-843 amplifier tubes of Figure 4. The bias voltage is supplied by a copper oxide rectifier 38, 81 equipped with a potentiometer 19 for adjusting the amount of bias voltage desired. Potentiometer 19 is provided with a smoothing condenser 55. The plate voltage is supplied by a single phase full wave rectifier 44, 37, 48 using one RCA-83 tube. This rectifier is provided with a 500 volt D. C. voltmeter 4 and a 200 ma. milliammeter 10 for measuring the plate power supplied to the amplifier 33—35.

The third part of the keying circuit (Fig. 4) is the 2500 volt keying bias rectifier. This is a single phase full wave rectifier using two UV-872-A tubes, for supplying negative voltage or blocking bias to the transmitter oscillator tubes.

The output of the rectifier tubes UV-872-A works through a choke coil 49 into a resistor unit 21 which is also the grid bias resistor for the transmitter oscillator tubes of Figure 9. The cathodes of this rectifier are connected to the anodes of the two UV-849 tubes (Fig. 4) which are connected in parallel. The latter pair of tubes have their cathodes connected to ground through an ammeter 11 to measure the rectifier keying current. The grids of the UV-849 tubes are connected to the cathode through a common resistor 22. These grids are also connected to the output of the tone signal amplifier rectifier (33—80) inclusive for keying. The filament voltages of all the tubes in the keying circuits are adjusted by a common rheostat 15 connected in the 220 volt

supply leads. A 300 volt A. C. voltmeter 6, connected across the 220 volt supply leads after the rheostat 15, indicates the filament voltage adjustment.

The jack panel (Fig. 1) supports two rows of twelve jacks each. The lower row of jacks is connected to the conductors in the telephone cable leading to the units in the tone room. The jacks in the upper row are connected to the circuits in the control unit (Figs. 4, 5, 6, 7 and 8).

The instrument panels on the control unit form a mounting for all of the meters, potentiometers and rheostats mentioned above. The switch 107 (Fig. 8) common to both control motors is also mounted in the center of these panels. The lower of these panels forms a mounting for two 5 volt rectifier type voltmeters 2, 2' (Fig. 6) to measure the voltages of the incoming tone signals from the tone room amplifiers. There is mounted in the middle of this lower panel a 15-0-15 milliammeter 8 (see Fig. 1). This meter is connected to the two signal pickup rectifiers 83, 83' (Figs. 10 and 13) in such a way as to indicate which transmitter channel is radiating. These pickup rectifiers 83 and 83' are of the copper oxide type and are mounted one under each pair of antenna transmission lines at the wall bushings. Rectifiers 83 and 83' deliver currents of opposite polarity to indicator 8 of Fig. 1 thereby causing the indicator needle to point to that recorder, such as 95 or 95', which at the time is in operation. It also indicates, of course, which channel is in operation.

Oscillator units (Figs. 9 and 12)

There are two of these units (see Figs. 9 and 12), one for each frequency. Each unit is mounted over its power amplifier. Referring to the short wave oscillator (Fig. 9), it is of the push-pull type using two UV-846 or ZP-131 tubes. The grid circuit is a tuned line TL 102 equipped with frequency compensation 103 for temperature changes. The temperature compensation system and the frequency controlling lines may be of the types described by C. W. Hansell in his copending applications Serial Nos. 24,510, filed June 1, 1935, and 692,092, filed October 4, 1933, respectively RCA dockets 9934 and 5512. The plate tank circuit is the customary tuned variable condenser 131 and coil 130 circuit. The oscillator tank circuit is inductively coupled by coil 129 to the grid circuit 429, 430 of the power amplifier (Fig. 10). The oscillator (Fig. 9) is provided with cross connected regeneration condensers 425. Plate and keying bias is supplied from the control unit through lead 901. The tuned line grid circuit consists of two concentric copper pipes one half wave length long, bent U shape, as described more fully in the copending application of C. W. Hansell Serial No. 692,092, filed October 4, 1933, RCA docket 5512.

The grids are connected to the inner pipe, a short distance each side of the center. It should be noted that the inner pipe is supported on insulators (not shown). The oscillator grid bias current and voltage is supplied through the center tap connection of the inner pipe, which connection includes coil 134 shunted by resistor 135. The two ends of this inner pipe have trombone action sections 102 for adjusting the transmitter frequency. The effect of the expansion of the inner pipe or line on the frequency due to temperature changes is compensated for by a thermostatically controlled condenser plate 901 mounted on hinges near the ends of the inner pipe or line.

The thermostat in this case is an oil filled brass pipe 902 fitted with a Sylphon bellows 904. A lever arm 103 operated by this bellows moves the condenser plate nearer to or further from the pipe ends. This changes the frequency by the same amount, but in opposite direction to that caused by temperature changes. The oscillator is provided with a water flow interlock 445 (Fig. 11) for each tube.

- 10 The oscillator panel supports an overload relay 67 of the electrical reset type for each oscillator tube, a 1.5 D. C. plate ammeter 13 for each tube, a 15 volt A. C. voltmeter 7, and selector switch 136 for measuring the filament voltage
- 15 of each tube, a 300 ma. D. C. milliammeter 12 to measure the oscillator rectified grid current and a 2500 volt D. C. voltmeter 5 to measure the oscillator D. C. bias voltage. The oscillator filament power is supplied from contactors 71, 72
- 20 (Fig. 11) located in the rear of the power amplifier unit. The filament dim resistors 111, 113 (Fig. 11) and the rheostats 16 (Fig. 9) and 416 (Fig. 10) are also in the power amplifier unit. The oscillator filament rheostat is controlled by
- 25 the same handle which controls the power amplifier filament rheostat. The anode cooling water for the oscillator tubes is supplied from the power amplifier water piping system.

Power amplifier units (Figs. 10 and 13)

- 30 There are provided two power amplifier units (Figs. 10 and 13) in this installation, one for each frequency.

- Two drain coils 138 are installed on each power amplifier. Inductive coupling is utilized in each power amplifier. It should be noted that all filament and plate push-buttons and the tap changing switch are disconnected, except the plate off button 421 which is connected in series with the
- 40 overload relay contacts. The power amplifier receives plate power from the main rectifier unit (Fig. 15). Negative bias voltage is supplied by the bias rectifier 450—405 in the power amplifier.

Main plate rectifier (Figs. 15 and 16)

- 45 A terminal board with tap changing links 79 is provided for manual operation. The A. C. plate power start 75 and running contactors 76 are installed in the basement (Fig. 16). Two auxiliary contactors 106 and 106A are supplied
- 50 to operate the two plate contactors 75 and 76.

- The mil-tap connection 1500 (Fig. 15) on the plate transformer secondary winding is brought out (and smoothing is provided) to supply half rectifier voltage for the oscillators. An electrical reset coil 69 (Fig. 16) is provided on the A. C. overload relay 210. A resistor 124 (Fig. 16) and a short circuiting contactor 123 is provided to
- 60 allow the rectifier filaments to run on reduced voltage when the transmitter is shut down and to bring this voltage up to normal when the transmitter starts operating. This keeps mercury from condensing on the rectifier anodes while the transmitter is shut down.

- 65 Another contactor 122 (Fig. 16) is provided to interlock the plate and filament voltages. This is accomplished by connecting the contactor coil across the filament transformer primary windings and by connecting the contacts in series with the door interlocks 1600 (Fig. 16). A thermostat 146 is mounted on the rectifier for use in
- 70 maintaining the air temperature above the critical value for the UV-869-A tubes of the main rectifier. The water pump starting switch 70
- 75 (Fig. 16) is mounted on the lower lefthand corner

ner of the rectifier panel. All push-buttons are disconnected. On the top of the main rectifier unit are mounted two disconnect switches 78 and 144 (Fig. 15) for the two power amplifiers and these switches connect the rectifier to the oscillators and power amplifiers while the down position connects the anodes of the oscillators and power amplifiers to ground. Behind the disconnect switches on the rectifier unit is mounted the transmitter plate selector switch

10 77.

This applies plate voltage to the proper oscillator and power amplifier. The two selector switches 77 are mechanically interlocked so that only one side can close at a time. A fuse holder

15 with horn gaps 143 is located near the plate selector switch and connected in series with the D. C. plate power bus for each oscillator. The relay reset rectifier 98 is installed behind the lower central panel of the main rectifier. This

20 small rectifier is of the copper oxide type.

Power panel (Fig. 17)

The top of this panel carries the disconnect switches 150 for the three phase, 2300 volt main

25 power supply which comes by cable from the main power house. A cable connects these disconnect switches to the main power transformer 149 in the basement. This transformer is 75 kva., 60 cycles, with a voltage rating of 2200 volts

30 to 220 volts. It supplies 220 volt, three phase power to operate the transmitter. A cable connects the three phase, 220 volt secondary winding of the power transformer 149 to a three pole, 400 amp. knife switch 89 at the bottom of

35 the power panel.

Above this switch are mounted four three pole, 60 amp. switches 90, 90, 93, 93 for distributing the power to the two power amplifiers, the water pump and the lighting transformer, etc. The power for the main rectifier is taken from the three pole, 400 amp. switch 89 at the bottom of

40 the power panel. The meters on the panel are as follows: One polyphase watthour meter 153, one 220 volt A. C. voltmeter 151 with a phase selector switch 152 and one water pressure gauge (not shown). All of the switches are fused and some other fuses are mounted on the rear of the power panel. The water pump is located in the basement as shown in Figure 16.

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III. DESCRIPTION OF START UP OPERATION

The start operation of the transmitter is as follows:

A tone is generated at the distant control station DCS (Figure 1) by means of generator G and sent out over a connecting line CL which eventually terminates in a plug TP at the tone

55 room.

If desired, the tone may be sent out from the distant control station as a modulation of high frequency waves. That is, the tone may be used to modulate, in amplitude, phase or frequency, waves generated at a distant radio transmitter. A suitable continuously operative receiver in the tone room may then be used to receive the radiated waves and reproduce the tones which are fed to the tone plug TP. Preferably the radio circuit, namely, the transmitting and receiving antennas, should be directive and directed upon

60 one another.

Two receivers, tuned to different wavelengths, and continuously operative may be used. These radio receivers are provided with output plugs and are continuously connected to jacks 100 and

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102 (Figure 1). In this case, at the distant control station, two transmitters operating at two different frequencies to which the receivers are tuned are provided. Or, if desired, one transmitter operative selectively at the receiver frequencies may be provided.

In the case of the wire line system of Figure 1, tone signal transmitted by closing key K, is plugged by means of the tone plug TP into one of the tone signal amplifiers of either Figure 2 or Figure 3 through either jack 100 or 102 (Figure 1). The amplified tone output from either tone amplifier of Figure 2 or Figure 3, that is, from output jacks 106, 108 or 110, 112, is plugged by means of suitable connecting or "patch" cords or conductors (not shown) into one of the two pairs of lines terminated in Figures 1 and 6 in jacks 136, 134 and 132, 130. In Figure 6 these jacks are connected by means of similar patch cords to jacks 608, 610 (Figure 6) or 612, 614 of Figure 6. Jacks 608-614 inclusive, are connected to the automatic start-stop and keying circuits of the long and short wave transmitters. Now assume specifically it is desired to start the short wave or high frequency transmitter channel. The incoming tone may, by means of tone plug TP, be connected to jack 100 (Figure 1) leading to amplifier A (Figure 2). The amplified tone signal from, say, tone amplifier A (Figure 2) and from output jacks 106, 108 (Figure 1) is plugged into a cable pair 134, 136 of cable X, which pair, in turn, is plugged into short wave transmitter jack 608, 610 (Figure 6), at, say, building #51. Amplified tone voltage is accordingly applied to transformer 30 of the start-stop circuit (Figure 7) and to transformer 33 of the keying circuit (Figure 4).

It should be stated here that the power is on transformer 39 (Figure 7) of the start-stop circuit at all times. This is supplied from switch 89 (Figure 17) through fuse cutout 155 (Figure 17) on the power panel.

The bias on tubes FG-57 (Figure 7) is set at about 10 volts by potentiometer 20. When the tone voltage exceeds about one half volt across the primary of transformer 30 as indicated by voltmeter 3 (Figure 6), the FG-57 "Thyratron" rectifier (Figure 7) starts functioning. It will be found best to adjust the volume control 17 (Figure 2) of the tone signal amplifier (Figure 2) at, say, No. 1 power house to give an output of two volts on volt meter 2 (Figure 2, Figure 6) key down or one volt on 50 per cent dots.

The rectified current from the FG-57 rectifier (Figure 7) passing through the coil of time delay relay 66, instantly pulls down the plunger. Relay 66 has a large capacity condenser 720 connected across its coil. Consequently, the plunger 722 will hold down on dots or dashes above six cycles per second, but the plunger will move up and down on slower speed sending or at intervals between messages. When the plunger of relay 66 (Figure 7) is pulled down, the lower contacts 724 are shorted. The controller motor 97 (Figure 7) is supplied with power through switch 107 (Figure 8) and power bus 800 (Figure 8). The return conductor 726 for motor 97 (Figure 7) is connected through the lower pair of contacts 724 of relay 66 (Figure 7), bus 728 through No. 801 disk (Figure 8) of controller 115 on the long wave side, then through bus 850 to disk No. 703 (Figure 7) on the short wave side to the other side 730 of the power bus 730, 732. This lifts magnetic brake 123 (Figure 7) and starts the short wave controller motor 97. After short wave con-

troller 115 has rotated four or five degrees, the circuit through No. 701 disk is broken so that motor 97' on the long wave side cannot start even though signal is subsequently applied to start-stop circuit E' (Figure 18 and Figure 8).

At the same time contact is made on disk 702 (Figure 7) on the short wave controller which short circuits the lower contacts 724 of relay 66. Consequently, the short wave controller will continue to be rotated by motor 97 regardless of further presence or absence of signal. At about ten degrees rotation contact is made on disk 705 and as a consequence the water pump 99 (Figure 16) will start and full voltage will be applied to the main plate rectifier filaments. It is to be noted that these filaments are normally partially energized at reduced voltage by the action of resistors 124 and 219 (Figure 16). This is desirable in order to prevent mercury condensation on the anodes of the rectifiers, thereby preventing arc backs which might otherwise occur. Application of pump current and full filament voltage is accomplished by the closing of switch 70 and contactor 123 respectively.

At forty degrees rotation contact is made on disk 706 (Figure 7) and all filaments on the short wave transmitter are put on dim (except the main rectifier and the start-stop circuit filaments which are already on, as before partially explained). This is accomplished by the closing of filament dim contactor 71 (Figure 11). The "tick-tock" time delay 1100 on contactor 71 operates the filament bright or running contactor 72, which shorts out resistors 111 and 113.

This applies usually in about seven seconds full filament power to the short wave radio frequency oscillator and power amplifier tubes. These tubes include all tubes of Figure 4 (the keying circuit); Figure 9 (short wave oscillator); and, Figure 10 (short wave power amplifier).

It should be noted that when contactor 72 (Figure 11) is operated, interlock switch 1102 is closed. This places voltage upon the common sides of coil 73, 74 (Figure 11), assuming, of course, that relay 121 is closed, thereby connecting together, by means of its armature, the contacts 1104. Generally, the purpose of relay 121 is to prevent application of plate voltage to the various rectifiers should filament supply be removed or fail for any reason until filament power has been re-instated for at least a minute. This will be explained more fully hereinafter.

When the controller 115 of Figure 7 is rotated 275° by motor 95, contact is made with disk 707 by the corresponding brush shown at the left. That is to say, as illustrated in the drawings, the brushes 7000 are stationary and the disks having the conducting and insulating segments are rotated past them. These vertically arranged brushes as shown in Figure 7 are provided with suitable connections 1 to 9 inclusive. Also, it should be stated in connection with Figure 7 that the motor is driven in such a direction as to rotate the controller counterclockwise as viewed from the motor end of the controller, or clockwise as viewed from a position above the controller.

Now, returning to the 275° position of the controller, when contact is made with disk 707 there results the application of reduced grid bias voltage to the oscillator tubes UV-846 of Figure 9. This reduced voltage is derived from the keying rectifier resistor 21 of Figure 4. In addition, reduced bias derived from rectifier tubes UV-872 (Figure 10) is applied to the power amplifier

tubes ZP-130 (Figure 10). In addition, reduced bias is applied to the RCA 843 signal amplifier tubes of Figure 4, which reduced bias is derived from rectifier 81 (Figure 4).

5 All these reduced biases are impressed upon the various tubes mentioned hereinabove by virtue of the closing of contactor 73 (Figure 11). The closing of contactor 73 first puts reduced plate voltage on the UV-372 power amplifier bias rectifier 450-405 (Figure 10), on the UV-372-A keying rectifier (Figure 4) and puts reduced voltage on the rectox bias rectifier 81 (Figure 4) for the RCA UV-843 tubes (Figure 4).

10 After several seconds delay the time delay relay 730 on contactor 73 (Figure 11) closes, which closes contactor 74. Contactor 74 short-circuits resistor 112. This short-circuiting action applies full alternating current voltage to the plate transformers of bias rectifiers 81 and UV-372-A (Figure 4) and also to power amplifier rectifier UV-372 (Figure 2) and therefore full bias voltage to all of the transmitter tubes of Figures 4, 9, and 10.

15 An interlock 731 on contactor 74 (Figure 11) closes the short wave side of the direct current plate supply selector switch 77 (Figure 15) which in turn completes the direct current plate voltage circuit to the radio frequency oscillator and power amplifier tubes of Figures 9 and 10. That is to say, closing of interlock switch 731 (Figure 11) causes current to flow in coil 1510 of the short wave selector switch 77 shown in Figure 15. In the 275° position it is to be noted, moreover, that interlock 1502 on selector switch 77 (Figure 15) is closed.

20 As will be explained more fully hereinafter, opening of the contactor 1502 of switch 77 (Figure 15) will stop the short wave 95 (Figure 1) from further recording.

25 At the 295° position of controller 1105 (Figure 7) contact is made with disk 708 by its corresponding stationary brush. This causes reduced plate voltage to be applied to the radio frequency oscillator and to the radio frequency power amplifier tubes of Figures 9 and 10 by the closing of auxiliary contactor 106 (Figure 16) which closes main contactor 75 (Figure 16). Reduced alternating current voltage is applied to the main rectifier tubes 167-A of Figure 15 because of the closure of contactor 75 (Figure 16).

30 After several seconds delay, contacts 1606 of the delay or "tick-tock" relay 1602 of contactor 75 (Figure 16) closes. This closes auxiliary contactor 106-A which in turn closes the main running contactor 76 (Figure 16). The closing of contactor 76 short-circuits the resistors 207 and full alternating plate voltage is applied to the radio frequency and as a consequence, full direct current voltage is applied to the radio frequency oscillator and power amplifier tubes of Figures 9 and 10.

35 The closing of contactor 76 (Figure 16) also closes interlock contactors 1600 and 1604. Closure of contactor 1600 of Figure 16 causes the time recorder 95 (Figure 1) and the tone room indicator to function since the interlocks 1502 (Figure 15) and 1600 (Figure 16) cause energization of relay 64 (Figure 1). Relay 64 (Figure 1) is supplied with energy of one or two polarities from rectifier 98 (Figure 16) causing the tongue or relay of 64 to move either to the right or to the left. When moved to the right the short wave time recorder 95 is energized from a local 110 volt 60 cycle power source shown in Figure 3, 75 which also energizes the primary of transformer

46 (Figure 1). The closing of contactor 1604 (Figure 16) applies plate power to the RCA 843 tubes in the signal amplifier (Figure 4) by way of the RCA 83 tube rectifier of Figure 4 since interlock 1604 applies alternating current power 5 through transformer 37 (Figure 4) to the RCA 83 rectifier. This permits the short wave transmitter to be keyed since signal may now be amplified by amplifier 33-35 (Figure 4) rectified by rectifier 80 and applied to the grids of the keying tubes UV-349 (Figure 4). Variation in the grid voltage on the UV-349 tubes of Figure 4 has its variation in the current flowing through resistor 21 from the rectifier tubes UV-372-A. In this manner resistor 21 which is connected to 15 the grids of the short wave oscillator tubes (Figure 9) keys the latter.

Incidentally, it might be noted at this point that when the long wave interlock 1512 (Figure 15) is closed by the contacting coil 1514, rectifier 98 of Figure 16 applies a relatively reversed voltage to the operating coil 164 of relay 64 (Figure 1) which causes the tongue of the relay 64 to move to the left placing the long wave recorder 95' (Figure 1) in operation.

20 At 310° rotation contact is made on disk 709 (Figure 7). This connects the alarm relay 63 (Figure 1) and over-load relay re-set button 86 (Figure 1) in the tone room to the coil of relay 65 (Figure 16) in the re-set rectifier 98 (Figure 16) through a back interlock 1608 (Figure 16) on the main plate running contactor 76. That is to say, should, for any reason, main contactor 76 open, contacts 1608 (Figure 16) will close. This in turn will close switch 65 (Figure 16). 25 Contact of relay 65 closes alarm 94 of Figure 1 since closure of 65 energizes the coil which closes contact 63 (Figure 1). By closing the over-load relay re-set 86 (Figure 1) the alarm 94 is shut off since relay 63 (Figure 1) is short-circuited or de-energized. Closure of the relay re-set 86 in addition, applies power to the re-set coils 69 for the over-load relays shown in Figures 9, 10, and 16.

30 At 315° rotation of the controller 115 (Figure 7), disks 702 and 703 break contact so that motor 97 and, consequently, controller 115, stops rotating. The transmitter is now in running position, that is to say, it is in condition to transmit radio signals. The foregoing start-up period requires about one and one-half minutes.

35 Summarizing the start-up of the short wave transmitter we find:

(1) The main plate rectifier filaments for the rectifier tubes 169-A (Figure 15) are always partially on. The filaments for the start-stop circuits, for the tubes of Figures 7 and 8 and for the tubes shown in the tone amplifier of Figures 2 and 3, are always on with full voltage. Tone coming in over the control line CL (Figure 1) is applied simultaneously to the short wave keying circuit (Figure 4) and to the automatic start-stop circuit (Figure 7). It is assumed that it is desired to run the short wave side of the system as before, the long wave operation being similar 65 when the long wave side is plugged in. Hence, for brevity, long wave operation will not be referred to specifically.

(2) Presence of the tone causes rotation of motor 97 and when the motor 97 rotates the short wave controller (Figure 7) approximately 5°, the motor circuit for the automatic start-stop circuit for the long wave side of the apparatus is broken. At the same time, the motor circuit for the short wave side of the apparatus is locked so as to con- 75

tinue rotation of the motor. This 5° rotation takes into account disks 701 and 702.

(3) At 10° rotation disk 705 comes into play as a result of which the water pump for the oscillator and power amplifier (Figures 9 and 10) is started and simultaneously full voltage is impressed upon the main plate rectifier filaments.

(4) At 40° rotation of the short wave controller all other filaments shown in the system are supplied with dim or reduced voltage due to the contact of disk 706 with its brush. A time delay relay then applies full voltage on all of the other filaments not heretofore energized, namely, full voltage is now placed upon the tubes of Figures 4, 9, and 10. At the same time, an interlock is worked to prevent plate voltage from being applied to various rectifiers until full filament voltage returns.

(5) At 275° rotation disk 707 of the short wave controller functions, causing reduced bias to be placed on the oscillator tubes of Figure 9, the power amplifier tubes of Figure 10, and the tone amplifier tubes 843 of Figure 4. This action also follows due to the closing of contactor 73 (Figure 11). A time delay relay subsequently causes application of full voltage and this time delay relay, moreover, closes the direct current plate circuit for the oscillator and power amplifier tubes of Figures 9 and 10. The closing of the direct current interlock also causes closing of an interlock switch system having a time recorder 95 shown in Figure 1, which recorder is cut out of circuit when the direct current plate circuit for either the oscillator or power amplifier is opened.

(6) At 295° rotation of the controller shown in Figure 7, reduced plate voltage is impressed on the plates of various rectifiers and consequently the plates of the oscillator and power amplifier tubes (Figures 9 and 10) are supplied with reduced direct current voltages. A time delay relay then comes into operation to cause full alternating voltage to be applied to the main rectifiers which results in full direct current potential applied to the plates of the oscillator and power amplifier tubes of Figures 9 and 10. At this time an interlock for the plate direct current circuit completes the circuit for the short wave time recorder 95 (Figure 1), and an additional interlocking system applies alternating current to a rectifier which in turn supplies plate voltage for the tone amplifier 33—35 of Figure 4.

(7) At 310° rotation of the controller (Figure 7) disk 709 functions to place the alarm and overload re-set systems in operating condition.

(8) At 315° disks 702 and 703 break contact, causing the motor driving the controller of Figure 7 to stop and leaving the short wave system in condition for radio transmission.

It is to be noted that only a few dots or a tone signal of short duration is needed to start up completely either the long or short wave side of the system.

Shut down procedure

The shutting down procedure is as follows:

The tone signal must be entirely removed as by removing tone plug TP (Figure 1) by opening of key K (Figure 1) or by other failure or absence of tone for a certain time to allow relay 66 (Figure 7) to function. Any intermittent signal on the control line CL (Figure 1) spaced less than, or closer than the time of operation of relay 66 is sufficient to keep the transmitter in operation. However, once the transmitter starts to shut down additional signal will not prevent complete shut

down. During the starting up operation, at 310° rotation it is to be noted that contact is made on disk 704 (Figure 7) which causes connection of the upper left hand contact of relay 66 to power bus 730. When the signal has been removed the plunger in relay 66 will move upward after a certain adjustable time delay. When the plunger of 66 moves up, it again starts motor 97 and controller 115 is again rotated in the same direction as before. That is when plunger 722 moves up, it closes the top contacts of the relay 66, completing the motor circuit 97 from bus 730 (Figure 8) through disk 704 (Figure 7) through the upper contacts of relay 66 (Figure 7) through motor 97 to the bus 800 (Figure 8) switch 107 15 and back to the other power bus 702 (Figure 8).

At 315° contact is again made on disk 702 (Figure 7) which short circuits the upper pair of contacts in relay 66 so that the transmitter will continue to shut down irrespective of signal conditions.

At 320° rotation disk 709 breaks contact. This opens the circuit to the alarm and relay re-set button in the tone room to prevent false alarm when the following step occurs:

At 330° rotation disk 708 (Figure 7) breaks contact. This opens auxiliary contactors (Figure 16) 106 and 106—A and contactors 75 and 76 respectively, which removes the plate power from the main rectifier (Figure 15) stops the time recorder 95 (Figure 1) (since 1600 of Figure 16, opens) and stops the transmitter keying (since 1604 opens removing plate power from the tone amplifiers) (Figure 5). Interlock 1603 (Figure 16) closes but since disk 709 (Figure 7) has broken contact no false indication is made on alarm bell 94 (Figure 1).

At 340° rotation, disk 707 breaks contact. This opens contactors 73 and 74 (Figure 11) which removes all bias voltage and opens direct current plate supply selector switch 77 (Figure 15). Interlock 1502 (Figure 15) is also opened, removing recorder 95 from circuit (Figure 1).

At 350° rotation disk 706 breaks contact. This opens contactors 71 and 72 (Figure 11) which removes all filament voltages from the power amplifier (Figure 10), oscillator (Figure 9), and the control unit (Figure 4) except that of the start-stop circuit (Figure 7), which always remains with plate and filament power on.

At 355° rotation disk 705 (Figure 7) breaks contact. This opens switch 70 and contactor 123 (Figure 16), which shuts down the water pump and removes full filament voltage from the main plate rectifier, but allowing the filaments to remain on reduced voltage.

At 360° rotation disk 702 breaks contact and shuts down short wave controller motor 97 and stops controller 115 from further rotation.

It is to be noted that at 325° rotation during the shutting down operation contact is made on disk 701 (Figure 7). This makes it possible for the second transmitter or channel to start up at this point in the shutting operation of the first or shutting down transmitter since by this time the load of one channel has been removed from the main plate rectifier. Disks 701 and 702 are making contact when the transmitter is in the shut down position. This completes the shutting down operation of the transmitter which requires approximately $\frac{1}{4}$ of a minute. After approximately $\frac{1}{2}$ of time required for shut down has elapsed, approximately the remaining $\frac{2}{3}$ of the shut down period may be used to start up other

channels thereby preserving time to change from one channel to another.

IV. OPERATION OF INTERLOCKS, OVERLOAD RELAYS, OVERLOAD RELAY RE-SET CIRCUIT, ALARM, RECORDERS AND INDICATORS WHEN SYSTEM IS IN RUNNING CONDITION

(A) Interlocks

(1) As diagrammatically shown, all access doors on the control unit (Figures 4, 5, 6, 7, 8) are interlocked to remove plate, bias, and filament voltage from the side of the unit which is opened, with the exception of the start-stop circuit (Figures 7 and 8) which has power on it at all times. The highest voltage in the start-stop circuit is the 440 volts A. C. for the FG-57 (Figures 7 and 8) anodes. As shown, each half of the control unit is interlocked with the oscillator and power amplifier with which it operates.

In other words, the door interlocks on each half of the control unit and the water and door interlocks on the oscillator and power amplifier with which it operates, are all connected in series with the common power supply for the coils of filament contactors 71 and 72 (Figures 11 and 14) for these units. Bias contactors 73 and 74 (Figures 11 and 14) are interlocked with the filament contactors 71 and 72 (Figures 11 and 14) to remove all plate power from the control unit (except the start-stop circuit) when any access door is opened.

The plate power for the tone keying amplifier (Figures 4 and 5) (using RCA-843 tubes) is interlocked by contacts 1604, 1604' (Figure 16) with the plate power contactors 75, 76 (Figure 16) of the main plate rectifier (Figure 15) so that the transmitter cannot be keyed until full transmitter plate voltage has been applied. As stated, this is accomplished by an interlock contact 1604, on running plate contactor 76 of the main rectifier which is connected in series with the power supply for plate transformer 37 (Figure 4) of the RCA-83 rectifier (Figure 4) that supplies plate power for the RCA-843 amplifier tubes (Figure 4).

All access doors on the power amplifier (Figure 10) are interlocked to remove all plate, bias, and filament voltage when any door is opened. These interlocks 412, 413, 445 (Figure 11) are connected in series with the common power supply for the coils of filament contactors 71 and 72 (Figure 11). Bias contactors 73 and 74 (Figure 11) are interlocked with the filament contactor by a contact 1102 on filament contactor 72 (Figure 11) which is connected in series with the common power supply for the coils of bias contactors 73 and 74 (Figure 11). Plate contactors 75 and 76 (Figure 16) and auxiliary contactors 106 and 106-A (Figure 16) are interlocked with the bias contactor by a contact 731 (Figure 11) on bias contactor 74 (Figure 11), which is connected in series with the power supply for the coil of auxiliary contactors 106 and 106-A (Figure 16).

The plate supply selector switch 77 (Figure 15) is also interlocked with the bias contactor by a contact 731 on bias contactor 74 (Figure 11) which is connected in series with the power supply circuit for the coil 1510 of selector switch 77 (Figure 15). The water interlocks 445 (Figure 11) of the oscillator and power amplifier units are connected in series with the door interlocks 412, 413 (Figure 11) so that the failure of the water supply would remove all filaments, bias and plate voltage. The above explanation in regard to door interlocks of course also ap-

plies to water interlock operation. There are no door interlocks on the oscillator units. 412 represents power amplifier door interlocks and 413 represents the control unit door interlocks. It is repeated that throughout this specification a specific description is given of the short wave channel only for brevity. Long wave operation is similar and the corresponding long wave elements are generally given by primed letters and numbers on the drawings.

The access doors on the main plate rectifier are interlocked to remove only the plate voltage when any door is opened. These door interlocks (1660, Figure 16) are connected in series with the power supply for the coils of auxiliary contactor 106 (Figure 16). The opening of contactor 106 also opens main plate contactor 75, auxiliary contactor 106-A and plate running contactor 76 (Figure 16) thus removing the plate voltage. The rectifier plate voltage is interlocked against failure of filament voltage by relay 122 (Figure 16). The coil of this relay is connected across the primary windings 1550 (Figure 15) of the filament transformers. The contacts of overload relay 210 are connected in series with the rectifier door interlocks 1660.

Overload relays

The contacts of the overload relays 67 and 67' (Figures 9 and 12) and 6710 and 6710' (Figures 10 and 13) for the tubes in the oscillator and the power amplifier (for each transmitter or channel) are all connected in series. These overload relay contacts are also connected in series with an interlock contact 1106 on bias contactor 74 (Figure 11) and through disk 708 of controller 115 (Figure 7). The aforementioned overload relay contacts and interlock disk and bias contact are connected in series with the common power supply lead 1662 for auxiliary contactors 106 and 106-A (Figure 16). The opening of any one of these contacts will remove the main plate rectifier power. The coils of these overload relays of course are connected between each filament transformer and ground for the tube to be protected.

The direct current overload relay 228 for the tubes in the main plate rectifier has its coil connected in the ground side of the direct current circuit. The contacts are connected in series with the contacts of interlock relay 122, in series with the door interlock contacts 1660 and in series with the power supply for the coil of auxiliary contactor 106 (Figure 16). The alternating current overload relay 210 has its coils connected in series with the alternating current power supply leads for the rectifier. The contacts of overload relay 210 are connected also in series with the door interlock contacts. The opening of any one of these contacts removes the alternating current plate power on the main rectifier.

Time delay relay for power failure

A time delay relay 121 (Figure 11) is provided to prevent the application of plate voltage, after a power failure, before the filaments of the mercury vapor tubes UV-872 (Figures 4, 10) and 169-A (Figure 15) have had sufficient time to reach operating temperatures. The coil of relay 121 (Figure 11) is connected across the filament power supply leads between fuses 434 and contactor 71 (Figure 11). The contacts of relay 121 are connected in series with the interlock contact 1102 on contactor 72 (Figure 11) and the common power supply lead 1108 for the coils of

bias contactors 73 and 74 (Figure 11). Relay 121 is adjusted for about one minute time delay.

Relay re-set circuit

Each overload relay in the remote control transmitter (with the exception of the direct current overload relay in the main plate rectifier, which is self-resetting) is provided with an electrical re-set coil 69 in addition to the usual hand re-set mechanism. These coils are all connected in parallel. They are connected to the alternating current power supply through pump switch 93 (Figure 17), fuse cutout 145 (Figure 16) and the contacts of relay 65 (Figure 16). One end of the coil of relay 65 is re-set rectifier 98 (Figure 16). The other end of the relay coil is connected to the re-set rectifier through controller disk 709 (Figure 7), re-set button 86 (Figure 1) and back through the ground return. If one or more of the overload relays trip out they may be re-set by momentarily pressing the re-set button 86 in the tone room while the transmitter is in the running position. After the transmitter has shut down the re-set circuit is automatically disconnected as before explained.

Alarm

When one or more transmitter overload relays trip out an alarm bell 94 (Figure 1) in the tone room unit will ring until the relays are re-set or until the transmitter shuts down. It should be noted that the transmitter will not shut down until the signal has been removed for a sufficient length of time. Power is supplied to alarm bell 94 from transformer 46 (Figure 1) through the contacts of relay 63. The coil of relay 63 is connected across the re-set button 86 through resistor 28. When the overload relays trip, the current through the coil of relay 63 (Figure 16) and resistor 28 (Figure 1) is sufficient to operate relay 63 (Figure 1) and ring the bell 94 without but insufficient to cause closure of the contacts of relay 65.

When push-button 86 (Figure 1) is operated it short circuits relay 63 with resistor 28 and the bell stops ringing. At the same time this closes relay 65 (Figure 16), which re-sets the overload relays. This closes main rectifier contactor 76 (Figure 16) through the auxiliary relays 108 and 106-A (Figure 16) and opens the back contact 1608 interlock in the re-set circuit. When the transmitter is shut down contact 1608 is closed but disk 709 (Figure 7) of the controller is then opened. Either operation opens the re-set circuit and stops the alarm ringing.

Time recorder

(1) There are two time recorders 95-95' (Figure 1) in the tone room units for recording the hours that the plate voltage is applied to each transmitter or channel. These are selectively operated by polarized relay 64 from a 115 volt line 166 (Figure 1). This source is fused by cutout 91 in the tone room unit. The coil 164 of polar relay 64 (Figure 1) is connected through an interlock contact 1600 on main rectifier plate contactor 76 (Figure 16) to two interlocks 1502 and 1512 on selector switch 77 (Figure 15). Interlock 1502 (Figure 15) on selector switch 77 connects by way of terminal 1601 (Figure 16) on the re-set rectifier to a voltage source 98 of one polarity while the other interlock 1512 (Figure 15) on selector switch 77 connects by way of terminal 1603 (Figure 16) on the re-set rectifier 98 to a voltage source of opposite polarity. Therefore, when the transmitter is running, the posi-

tion of selector switch 77 (Figure 15) determines which recorder (95 or 95') will register. Of course, when the transmitter is put in operation, the connections of terminals 1601 and 1603 on the re-set rectifier 98 should be made so that the proper recorder will operate for the proper channel.

Indicators

There are two radiation indicating meters 8 (Figure 1) and 6008 (Figure 6). These meters indicate which transmitter or channel is radiating, that is, a pointer deflection to the left indicates that the long wave channel is operating and a pointer deflection to the right indicates that the short wave channel is operating. This is accomplished as follows: One terminal of each meter (same polarity) is connected to ground through about approximately 100 ohms resistance as shown.

The other terminals of the two meters 8 and 6008 are connected together and to the midpoint between two 1000 ohm resistors 26 (Figure 6). The other ends of resistors 26 are connected to rectifiers 83-83' (Figures 10 and 13) which are of opposite polarity. One of these rectifiers is coupled to the antenna transmission of one channel at the wall bushings and the other rectifier is coupled to the antenna transmission of the other channel at the wall bushings. The difference in polarity of the rectified currents indicates which channel is radiating.

There are also two indicator lamps 116 and 116' (Figure 1) mounted on the tone room unit which indicate which transmitter is supplied with plate voltage. Each of these lamps 116 is connected by a resistor across its respective time recording meters 95 as shown in Figure 1.

Each overload relay is preferably equipped with a flag which indicates when the relay has been tripped.

V. DESCRIPTION OF THE SIGNALLING OPERATION

Assume that the tone room signal amplifiers of Figures 2 and 3 are plugged through to jacks 608, 610 and 612, 614 in the control unit (Figure 6) of the remote control transmitter. A tone signal is then plugged by plug TP (Figure 1) into either input jack 100 or 102 of the desired tone room signal amplifier such as shown in either Figures 2 or 3. Volume control 17 (Figure 2) (assuming tone plug TP is plugged into jack 100) should be adjusted to give an output voltage on meter 2 (Figures 2 and 6) of 2 volts key down or 1 volt on 50% dots. This signal will reach input transformer 33 (Figure 4) of the tone amplifier in the control unit using the RCA-843 tubes. The amplified tone signal is rectified by "Rectox" rectifier 80 which delivers a negative direct current voltage output in lead 400. Bias potentiometer 19 should be adjusted to give about 260 volts, key down, on meter 3 (Figure 4).

In the key down condition, the negative direct current output voltage of RCA-843 amplifier and rectifier 80 (Figure 4) is applied to the grids of the UV-849 tubes (Figure 4) in the keying circuit. This cuts off the plate current in these tubes and stops rectification in the UV-872-A (Figure 4) keying rectifier, so that there is no negative blocking voltage output from this rectifier. That is, when tubes UV-849 (Figure 4) are cut off, current flow from the keying rectifier through resistance 21 is cut off thereby allowing resistor 21 to act as the oscillator (Figure 9) grid leak. When this condition takes place the oscillator functions practically instantly and the radio

frequency signal is amplified in the power amplifier (Figure 10) and radiated by the short wave antenna (not shown).

In the key up condition, the output voltage of the RCA-843 tone amplifier (Figure 4) and rectifier 80 is zero. Consequently, resistor 22 maintains the UV-849 grids (Figure 4) at ground or filament potential during this time and keying rectifier plate current (Figure 4) is allowed to flow. In this case, the UV-872-A keying rectifier (Figure 4) is permitted to function, which impresses a high negative direct current voltage (about 2000 volts) on resistor 21 (Figure 4). This puts a high negative direct current voltage on the grids of the oscillator tubes (Figure 9) which blocks the plate current and instantly stops the functioning of the oscillator so that the radiated signal is stopped instantly. In this manner the dot and dash signals are transmitted. The long wave side operates similarly, corresponding parts being given by similar primed numbers.

VI. OPERATION OF THE FREQUENCY COMPENSATOR

This apparatus (shown in Figures 9 and 12) maintains approximately constant transmitter frequency by compensating for the effect of temperature changes on the natural oscillating frequency of the frequency control line. It is described more fully in the copending application of C. W. Hansell and G. L. Usselman Serial No. 24,510 filed June 1, 1935 (RCA docket No. 9934). As the temperature of the lines TL (Figure 9) or TL' (Figure 12) and the air around them rises the natural tendency is for the line to expand or increase in length. This causes a decrease in the oscillating frequency. However, the oil in the pipe 103 and bellows 105 expands and moves the lever arm 904 in such a way as to move the condenser plate 900 away from the ends 102 of the line. This latter movement has the effect of increasing the frequency. A decrease in line temperature decreases the length of the line and tends to increase the frequency but the compensator system, by reason of the contracting oil in the pipe and bellows, through the motion of the lever arm, moves the condenser plate closer to the ends of the line and tends to decrease the frequency by the same amount. When this condenser plate movement is adjusted to the proper amount, it will exactly compensate for the frequency change due to temperature change of the line.

VII. IMPORTANT ADJUSTMENTS

Keying circuit (Figure 4)

Generally the output voltage of the tone room amplifiers (Figures 2 and 3) should be adjusted for two volts key down or for one volt with 50% dots. Bias potentiometer 19 (Figure 4) should be adjusted so that the reading of ammeter 11 (Figure 4) with 50% dots is one half of the reading with key down. This is usually obtained when voltmeter 3 (Figure 4) reads about 260 volts, key down.

Oscillator and power amplifier tuning

The tuning adjustments of the oscillator and power amplifier grid circuit is as follows:

The preliminary adjustment is to turn the oscillator plate condenser 131 (Figure 9) to the point where the circuit oscillates, and then adjust the power amplifier grid circuit 429 (Figure 10) for maximum rectified grid current with the power amplifier plate voltage off. The plate voltage is then put on the power amplifier. This

will buck down the grid current, due to secondary emission in the power amplifier tubes, and change the loading on the oscillator (Figure 9). The oscillator plate tuning should now be turned in the direction of increasing power amplifier grid current until the oscillator breaks or stops oscillations. From this point the tuning condenser 131 (Figure 9) should be turned back a few degrees until the oscillations start again as indicated by current flow through grid ammeter 12 (Figure 9). This last adjustment is a sort of compromise which consists of getting the maximum amount of oscillator grid current or excitation without sacrificing too much power amplifier grid current or excitation. The oscillator regeneration condensers 425 should not be moved since they are now adjusted at the most satisfactory point. Neither should the oscillator output coupling 129 be changed for the same reason.

Frequency adjustment (Figures 9 and 12)

Relatively large changes in frequency can be made by adjusting the length of the line oscillator. This may be accomplished by loosening the clamps and sliding the trombone sections 102 on the ends of the line in or out to increase or decrease the frequency, after which adjustment the clamp must be tightened. In this case, a sixteenth of an inch movement will change the oscillator frequency in the order of 2 to 4 k. c.

Relatively small changes in frequency can be made by adjusting the position of frequency compensation condenser plate 900. One turn of the thumb nut TN on the outer end of the lever arm will change the oscillator frequency about several hundred cycles. Too large a change in the position of condenser plate 900 will effect the operation of the frequency compensator.

Frequency compensation adjustment

The degree or amount of frequency compensation per degree of temperature change may be changed by changing the length of the lever arm 904 in either compensator system. It is recommended adjustments be made to approach as nearly as possible flat compensation.

Room temperature

The room temperature should not be allowed to fall below 59 degrees or rise above 120 degrees F., in order to prevent arcbreaks in all of the mercury vapor rectifier tubes. A thermostat 146 (Figure 16) and contactor 1700 (Figure 17) are provided for heaters to warm the air about the tubes. A ventilator may also be provided to supply cool air in the event temperature increase is too great.

Before any work on the transmitter circuits is started, the main power switch 89 (Figure 17) should be opened. This removes all transmitter power. After this switch is closed it requires from 3 to 5 minutes for the FG-57 tubes (Figure 7) to reach operating temperature.

Miscellaneous

The hummer 96 in the tone room is provided for test purposes for keying the transmitter. This supplies about 2 volts, 1000 cycle tone which may be plugged directly into the transmitter tone line plug 134, 136 or 130, 132 (Figure 1) without the use of the tone room signal amplifiers (Figures 2 and 3). The hummer may be started by closing a toggle switch 87 (Figure 1) and its output tone may be keyed by telegraph key 88.

Potentiometers 27-27 (Figures 1 and 6) are provided for transmitter indicator meters 8-8

(Figures 1 and 6) to reduce earth current reading and for the purpose of equalizing the signal indication readings.

If a signal be simultaneously applied to both transmitters for starting purposes, there is a very remote chance that both will start simultaneously until contact is broken on both No. 701 controller disks (Figure 7) in which case both transmitters would stop in that position and would be unable to start up or shut down. This predicament may be solved by shorting circuit terminals 1-1 for disk 701 (Figure 7) on controller 115 of one transmitter until the other transmitter has started up and shut down. The short circuit then should be immediately removed. After this procedure the transmitters will function normally.

Disconnect switches 78 and 144 (Figure 15) are provided so that the plate circuits of the power amplifiers and the oscillators may be disconnected from the main plate rectifier and grounded to protect any one working on these circuits.

An auxiliary copper tank 2000 (Figure 20) with a float valve 2002 connected to the water supply pipe and to the cooling pond (not shown) is provided to maintain the water supply in the cooling pond. A drain valve 2004 is also provided in the water circulating system for discharging surplus water from the cooling system which accumulates due to rain and snow. The water pump (Figure 20) must be running in order to drain water from the pond. The drain valve 2004 should never be left open because this would eventually drain all the water from the cooling system.

The cooling water is fed to the oscillators and power amplifiers (Figures 9, 10, 12, and 13) as described more fully in patent to H. E. Hallborg #1, 963,131, June 19, 1934.

It is to be noted that the jack panel of Figure 1 may be located at any convenient point. In fact, it may be placed adjacent the generator G and key K of Figure 1. In this case, the operator of generator G and key K may remotely control the complete system. On the other hand, if desired, the tone generator and the key K may be located at some distant control system DCS, as indicated in Figure 1 and simply a telegraph bar or control line CL brought to any suitably located tone room such as indicated by Figure 1. There, an operator in telegraphic and telephonic communication with the distant control station DCS may control the operation of either the short wave channel or the long wave channel.

Preferably, the tone generator G (Figure 1) is located at some distant point, say in a city, and a control line CL brought out to a suitable transmitting site. At the transmitting site the apparatus shown in Figures 1, 2, and 3 may be located at some central building and the remainder of the apparatus located in a removed transmitter building. This system may be duplicated with other control lines brought into the central building and with independent separated transmitter buildings provided for additional pairs of long and short wave channels. This is advantageous since it separates the radio frequency transmitters from one another, eliminating interference and cross-talk. Heretofore when the tone amplifiers and a plurality of transmitters were located in a common building, much trouble was encountered because of the fact that the tone amplifiers would pick-up radiations from various undesired transmitters producing many

difficulties such as cross-talk and interference. This required elaborate and expensive shielding and filtering of the tone amplifiers. On the preferred form of layout, as before described, the central building may be shielded as a whole but since the radio transmitters are located at a distance, the need for expensive individual shielding and filtering is minimized. A further advantage of the preferred arrangement resides in the fact that the oscillator and power amplifier may be located relatively close to their cooperating antennas thereby eliminating relatively long high loss radio frequency transmission lines heretofore required when all the transmitters were located at a central building.

As a further modification, a pair of tone lines each connected to the input jacks 100, 102 (Figure 1) may be brought in to the distant control system DCS (Figure 1). There, an automatic transmitter may be keyed into tone line so that at the distant control station DCS either the long wave or the short wave channel may be operated. Obviously, the key and tone generator K and G (Figure 1) may be replaced by any suitable automatic transmitting apparatus or multiplex tone keying system. When the pair of tone lines, each leading to the input jacks 100 and 102 are brought into the distant control station DCS (Figure 1). The distant control station may then operate either the long wave or the short wave channel from the distant control station.

By making suitable changes both channels may be operated simultaneously with the same or different signals. When this is done, however, the output of each channel is approximately half of the full power output for the rectifier in order to prevent over-loading the rectifier. This may be accomplished in the following way:

Turning to Figures 7 and 8, disks 701 and 801 are short-circuited. This will enable either channel to be started up independently or concurrently with the other channel. The starting up of both of them is contingent upon supplying tone to both the input jacks 100, 102 of Figure 1. A further change is made in contactor 77 (Figure 15) in that the mechanical interlock is removed so that both the short wave and long wave sides may be operated simultaneously. Another change which should be made is that the coupling to each antenna should be reduced so as to properly load the power amplifier when operated at approximately half output.

As already pointed out, the tone lines may be replaced by low power radio transmitters and a continuously operating receiver or receivers, the latter having audio frequency circuits properly plugged into the input jacks 100, 102.

Having thus described our invention, what we claim is:

1. In combination in a high power short wave radio transmitter, a plurality of radio frequency generating and amplifying units, an antenna individual to each of said units, a common energy supply source for said units, a source of control voltage, means responsive to voltage from said source for selectively connecting said units to said energy supply source, and means for preventing connection of another unit to said energy supply source until the unit connected thereto is disconnected.

2. In combination, a first radio frequency generator, a first power amplifier for amplifying the output of said generator, a second radio frequency generator, a second power amplifier for

amplifying the output of said second generator, an antenna individual to each of said first and second power amplifiers, a source of keyed voltage, a common source of energizing current, means responsive to the keyed voltage to connect one of said generators and one of said power amplifiers to said source of energizing current, and means operative upon removal of said keyed voltage to prevent connection of the other power amplifier and generator to said source of energizing current until a definite time interval has elapsed.

3. Apparatus as claimed in claim 2 characterized by the fact that said keyed voltage is a keyed alternating current of audio frequency.

4. In a signalling system, an oscillation generator, a power amplifier for amplifying oscillations from the generator, a plate rectifier for supplying plate voltage to the generator and power amplifier, means continuously operative to maintain the filaments of said rectifier partly energized, means for supplying cooling fluid to said oscillation generator and power amplifier, means for supplying grid bias to the oscillation generator and power amplifier, means for supplying filament heating current to the oscillation generator and power amplifier, a start-stop control circuit, a source of keyed tone voltage and means responsive to said keyed tone voltage for starting up said automatic start-stop circuit whereby the following events sequentially occur; (a) said start-stop circuit is locked in running condition; (b) cooling fluid is caused to flow to said oscillator and power amplifier and full energization of the filaments of said rectifier is effected; (c) the filaments of said power amplifier and oscillator are energized; (d) bias voltage is applied to the oscillator and power amplifier; (e) the plates of the tubes in said rectifier are energized and the rectified voltage applied to the plates of the oscillator and power amplifier; and (f) the start-stop circuit is stopped and the transmitter system left in running condition.

5. The system as claimed in the preceding claim characterized by the fact that means are provided for applying voltage to the filaments of the oscillator and power amplifier and to the plates of the rectifier in two steps.

6. Apparatus as claimed in claim 4 characterized by the fact that means are provided to apply filament voltage to the plates of the oscillator and power amplifier in two steps and being further characterized by the fact that means are provided to prevent the application of plate voltage to the rectifier until full filament voltage is applied to the filaments of the rectifier tubes.

7. Apparatus as claimed in claim 4, characterized by the provision of means, responsive to the application of one or more tone signal impulses, to cause the series of start up operations to commence immediately, and being characterized by the provision of means responsive to operation of the preceding means, causing completion of the series of start-up operations until the system is placed in its full operating condition despite cessation of tone impulses.

8. Apparatus as claimed in claim 4, characterized by the provision of means, responsive to the application of one or more tone signal impulses, to cause the series of start up operations to commence immediately, and being characterized by the provision of means responsive to operation of the preceding means, causing completion of the series of start-up operations until the system is

placed in its full operating condition despite cessation of tone impulses, and being further characterized by the provision of means, operative only after absence of a tone voltage for a predetermined period of time to cause shut down of the system.

9. Apparatus as claimed in claim 4, characterized by the provision of means, responsive to the application of one or more tone signal impulses, to cause the series of start up operations to commence immediately, and being characterized by the provision of means responsive to operation of the preceding means, causing completion of the series of start-up operations until the system is placed in its full operating condition despite cessation of tone impulses, and being further characterized by the provision of means operative only after absence of a tone voltage for a predetermined period of time to cause shut down of the system, and being still further characterized by the provision of means to cause complete shut down once the system starts shutting down despite reinstatement of the tone signal during the shut down series of operations.

10. Apparatus as claimed in claim 4, characterized by the provision of means, responsive to the application of one or more tone signal impulses, to cause the series of start up operations to commence immediately, and being characterized by the provision of means responsive to operation of the preceding means, causing completion of the series of start-up operations until the system is placed in its full operating condition despite cessation of tone impulses, and being further characterized by the provision of an additional system as claimed in claim 5, and means interlocking said systems so as to prevent starting up of one when the other is being started up or is in running condition.

11. Apparatus as claimed in claim 4, characterized by the provision of means, responsive to the application of one or more tone signal impulses, to cause the series of start up operations to commence immediately, and being characterized by the provision of means responsive to operation of the preceding means, causing completion of the series of start-up operations until the system is placed in its full operating condition despite cessation of tone impulses, characterized by the provision of an additional system as claimed in claim 5, means interlocking said system so as to prevent start up of one when the other system is being started up or is in running condition, and means permitting the starting up series of operations for one system after the other has started, but not yet completed its series of shut down operations.

12. In a signaling system, in combination, a rotatable controller, a motor for driving said controller, a discharge device operatively connected with the control circuit of said motor, a source of control voltage, means for applying voltage from said source to said device for rendering operative said control circuit thereby causing rotation of said motor and thereby causing rotation of said controller, an oscillation generator, a power amplifier for amplifying oscillations from the generator, a plate rectifier for supplying plate voltage to the generator and power amplifier, means continuously operative to maintain the filaments of said rectifier partly energized, means for supplying cooling fluid to said oscillation generator and power amplifier, means for supplying grid bias to the oscillation generator and power amplifier, means for supplying

filament heating current to the oscillation generator and power amplifier, and means responsive to rotation of said controller whereby the following events sequentially occur: (a) said controller is locked in running condition; (b) cooling fluid is caused to flow to said oscillator and power amplifier and full energization of the filaments of said rectifier is effected; (c) the filaments of said power amplifier and oscillator are energized; (d) bias voltage is applied to the oscillator and power amplifier; (e) the plates of the tubes in said rectifier are energized and the rectified voltage applied to the plates of the oscillator and power amplifier; and (f) the controller circuit is stopped and the transmitter system left in running condition.

13. In combination, a pair of radio frequency transmitters, a common rectifier, means for selectively operating either of said transmitters with full power from said rectifier and means whereby both of said transmitters may be operated simultaneously at approximately half power.

14. Apparatus as claimed in the preceding claim characterized by the fact that means responsive to tone signals are provided for causing excitation of either or both of said transmitters with voltage derived from said rectifier.

15. In combination, a transmitter, a keying amplifier operatively connected to said transmitter, a main plate rectifier for said transmitter, a subsidiary plate rectifier for said amplifier, means for applying full plate voltage from said main rectifier to said transmitter, and means responsive to the operation of said last mentioned means to prevent the application of voltage to said amplifier from said subsidiary rectifier until full plate voltage is applied to said transmitter.

16. In combination, a pair of radio transmitters, high frequency output circuits coupled to each of said transmitters, means for causing selective operation of either of said transmitters, a two way indicator unit, circuits coupling said indicator unit to each of said output circuits, said circuits being so connected to said indicator unit that high frequency energy in one of said output circuits causes one indication of said indicator unit, and in the other of said output circuits another indication whereby said indicator unit automatically indicates which of said transmitters is selectively operated.

17. In a signaling system, in combination, a movable controller, means for driving said controller, a discharge device operatively connected with the control circuit of said driving means, a source of control voltage, means for applying voltage from said source to said device for rendering operative said control circuit thereby causing movement of said driving means and thereby causing movement of said controller, an oscillation generator, a power amplifier for amplifying oscillations from the generator, a plate rectifier for supplying plate voltage to the generator and power amplifier, means continuously operative to maintain the filaments of said rectifier partly energized, means for supplying cooling fluid to said oscillation generator and power amplifier, means for supplying grid bias to the oscillation generator and power amplifier, means for supplying filament heating current to the oscillation generator and power amplifier, and means responsive to movement of said controller whereby the following events sequentially occur: (a) said controller is locked in moving condition; (b) cooling fluid is caused to flow to said oscillator and power amplifier and full energization of the

filaments of said rectifier is effected; (c) the filaments of said power amplifier and oscillator are energized; (d) bias voltage is applied to the oscillator and power amplifier; (e) the plates of the tubes in said rectifier are energized and the rectified voltage applied to the plates of the oscillator and power amplifier; and (f) movement of the controller is stopped and the transmitter system left in running condition.

18. In combination, a pair of radio transmitters, a high frequency output circuit coupled to each of said transmitters, a single plate voltage rectifier for said transmitters, a source of control voltage, means responsive to voltage from said control voltage source to cause selective energization, starting up and operation of either of said transmitters by selective connection to said plate voltage rectifier, a pair of time recorders, means selectively responsive to said selective energizing, starting up and operating means for selectively operating one or the other of said time recorders depending upon whether one or the other of said transmitters is selectively energized and operated, and means operating independently of control voltage from said control voltage source to prevent starting up and connection of either transmitter to the rectifier until the transmitter connected thereto has been disconnected.

19. In combination, a pair of radio transmitters, a high frequency output circuit coupled to each of said transmitters, a single plate voltage rectifier for said transmitters, means to cause selective energization and operation of either of said transmitters by selective connection to said plate voltage rectifier, a pair of time recorders, means selectively responsive to said selective energizing and operating means for selectively operating one or the other of said time recorders depending upon whether one or the other of said transmitters is selectively energized and operated, and being further characterized by the fact that a polarized relay operatively connected with said energizing and operating means is provided to selectively operate said recorders, and being still further characterized by the provision of means supplying electrical energy of one polarity to said relay when one transmitter is selectively operated and of another polarity when the other transmitter is selectively operated.

20. In apparatus of the character described, a source of keyed tone signals, means rectifying said keyed tone signals, a keying tube having an anode, a cathode connected to ground for direct current and a control grid, means subjecting the control grid and grounded cathode of said keying tube to the rectified tone signals, a second rectifier arranged to rectify energy derived from a source of alternating current, a resistor grounded at one end, said resistor, second rectifier and the anode and cathode of said keying tube being connected in series, a high frequency tube having a pair of electrodes to be subjected to keyed voltages, and means connecting said pair of electrodes of said high frequency tube to a portion of said resistance.

21. In combination, a high voltage full wave tube rectifier having a pair of plates excited in phase opposition with energy to be rectified and having cathodes directly connected together, a resistor connected between the plate circuit of said rectifier and directly to ground, a keying tube having a plate, a cathode and a grid, the plate of said keying tube being connected to the cathodes of said rectifier, the cathode of said

keying tube being connected to ground, a source of keyed tone, a rectifier rectifying tone from said source, means to apply rectified tone voltages to the grid and cathode of said keying tube, a high frequency tube, and means, including a direct current resistor, connecting a pair of electrodes of said high frequency tube to the resistor

connected between the plates of said rectifier and directly to ground.

22. Apparatus as claimed in the preceding claim, characterized by the fact that the tone rectifier is of the full wave copper oxide type.

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